SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1899.

GENERAL PHYSICS.

537. *Vibration of Apparatus.* **A. Broca.** (Journ. de Physique, 7. pp. 648–650, 1898.)—This paper contains a description of some experiments made to determine in how far sensitive apparatus, if placed on rubber blocks, is protected from the vibrations of the building. If the apparatus is of a rigid type, and has no movable parts with natural periods of the order of one second, *e.g.*, a telescope or optical apparatus, the rubber blocks serve as perfect insulators against the vibrations. If, however, the apparatus has a movable system, like a d'Arsonval galvanometer, the vibrations, instead of being diminished by the rubber, are increased, the rubber serving as a flexible support on which the apparatus vibrates with a much longer period; it therefore influences the movable system much more than when the period of vibration is short. The results are similar to those previously obtained by the author (see 1898, Abstract No. 234). J. B. H.

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538. *Torsion and Recalescence of Steel.* **G. Moreau.** (Comptes Rendus, 128. pp. 292–294, 1899.)—Beyond a torsion of 58° per cm., the permanent torsion of a steel pianoforte wire varies in proportion to the initial tension T. In wires of different thicknesses, $T - T_r$ is inversely proportional to the diameter, so that for an initial torsion which is sufficiently great one can write—

$$T_r = T - \frac{k}{d}$$

Hence the laws for steel are analogous to those of soft iron, the only difference being that the permanent torsion sets in later in the case of steel. The constant k varies very rapidly in the neighbourhood of the point of recalescence and of maximum tempering, and thus furnishes a new means of determining these two points exactly. It retains its initial value 0·0056 until 290°, then diminishes up to the temperature of recalescence, 715°, and remains constant after that, at a value 0·0018. E. E. F.

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539. *Ductility of Copper.* **H. Bouasse.** (Comptes Rendus, 128. pp. 291–292, 1899.)—The specimens examined are copper wires newly drawn and those aged by heating to 200° for 1 to 100 hours. The ductility curves are well represented by the formula—

$$p=p_0+\mathrm{A}\sqrt{\log\frac{l}{l_0}-\frac{l-l_0}{l_1}}$$

where p is the pull, l_0 the initial length, l the length on removing the pull, *i.e.*, after deducting the temporary stretching, and p_0, A_1, and l_1 are constants, p_0 being the limiting pull at which permanent stretching sets in. This limit decreases with prolonged heating. If p_1 is the pull given by the above formula for the case of $l=l_1$, which is very near the point of rupture, $p_1\ l_1$ is sensibly constant whatever the duration of the ageing process. E. E. F.

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540. *Tidal Analyser.* **R. A. Harris.** (Phys. Rev. 40. pp. 54–60, 1899.)—For the stencil sheets used in the tide summations of the U.S. Coast and Goedetic Survey are substituted a number of cylinders, each representing a single component for, say, a period of 370 days. The circumference of each cylinder is divided into 370 equal parts, each division fixing a line or element which represents a day. The recording or adding apparatus for each kind of summation consists of two series of toothed wheels, all wheels of a series being upon a common shaft; the number of teeth upon each wheel of the first series may be taken as 300, and of the second series 299. The cylinders control the 300-tooth wheels by means of levers, one for each wheel. The twenty-five levers for each component are upon a common axis parallel to the axis of the cylinder. At one end of the lever is a pin or projection for entering the holes in the surface of the cylinder, while at the other end is a sharp edge extending upward for engaging the wheel above, thereby stopping its motion. Since the preventing of a wheel from rotation with its shaft must give rise to friction and wear, it is best to stop but one out of each 25, rather than stop 24 of them. This involves no extra work except the subtracting of the final machine readings from a constant number, the grand total of all hourly heights. E. E. F.

541. *Molecular Weight and Density of Fluids.* **D. Berthelot.** (Comptes Rendus, 128. pp. 553–556, 1899.)—There is a rigorous proportionality between the molecular weights of gases and their limiting densities at zero pressure. These limiting densities are equal to the product $d\ [1-(A_0^p)_t\,p]$, where d is the density at pressure p and temperature t, and $(A_0^p)_t$ is the coefficient of divergence of gas at t° with respect to Boyle's law, between the infinitesimal pressure p_o and the experimental pressure p. This expression is perfectly general and applies to all fluids, whether in the liquid or the gaseous state. Applied to liquids, it offers the advantage of connecting their molecular weight and their density, with the aid of the law already applied to gases, that is to say, the Avogadro-Ampère law regarded as a limiting law. It is the most direct method for determining the molecular weight of liquids.

If the characteristic equation of the fluids, $f(p, v, t)=0$, were accurately known, $(A_0^p)_t$ could be calculated, but it is only imperfectly known at present. Still, the formula of van der Waals constitutes a first approximation and gives a network of curves which, without coinciding with those of Amagat, follow their general aspect and characteristics. But the law of corresponding states has a greater generality than even van der Waals' equation. Let p_c, T_c, v_c be the critical pressure, temperature, and volume of a body. If we put $\omega=\frac{p}{p_c}$, $\theta=\frac{T}{T_c}$, and $\upsilon=\frac{v}{v_c}$, the function $\Phi(\omega, \theta, \upsilon)=0$ is the same for all bodies, and for very small pressures the characteristic equation tends towards the form $pv=RT$, R being a constant characteristic of the molecular weight of all substances. Calculation shows that—

$$1-(A_0^p)_t\,p=k\,\frac{\omega\upsilon}{\theta}$$

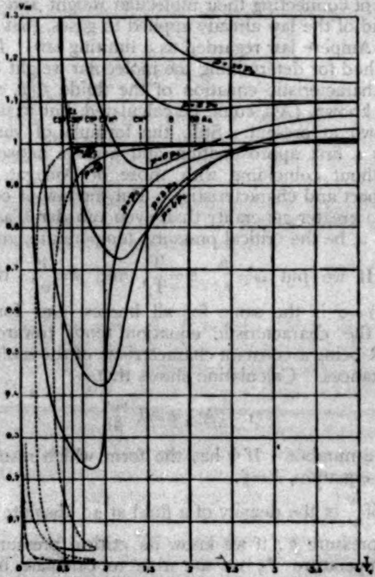
where k is a number. If Φ has the form which results from van der Waals' equation, $k=\frac{3}{8}$.

Hence, if $\frac{1}{v}$ is the density of a fluid at an absolute temperature T° and a pressure p; if we know its critical pressure p_o and its critical temperature T_c, we are able to calculate its molecular weight. The quantity $1-(A_0^p)_t\,p$ may be represented by v_m, as it is the real volume occupied by 1 molecule of the fluid, the unit being the volume occupied by 1 molecule of the perfect gas under the same circumstances. The result of the calculations from the formula are shown in the diagram.

The molecular volumes v_m are the ordinates, the reduced temperatures $\frac{T}{T_o}$ are the abscissæ, and the curves are traced for different values of $\frac{p}{p_o}$. If Avogadro's law were accurate, we should have $v_m=1$ for all temperatures and pressures. Hence the curves show the divergences from Avogadro's law. The curve $p=p_o$

shows an infinite v_m at the absolute zero of temperature, since there the gaseous volume is infinitesimal and the liquid volume is finite. The curve $p=p_c/66{\cdot}67$ corresponds to most bodies under ordinary conditions.

To compare these curves with experiment, the positions occupied by various bodies at 0° C. are shown. Drawing ordinates through these points, and taking their intersections with the curves, values for v_m at various pressures are obtained. For hydrogen, which is far outside the limits of the diagram, the curve indicates $v_m=1{\cdot}00014$ and experiment $1{\cdot}00019$. Among



the liquefiable gases, such as C_2H_4, CO_2, and SO_2, the theoretical curve diverges more slowly from the straight line $v_m=1$ than the real curve. Thus for SO_2 the curve gives $v_m=0{\cdot}987$, and experiment $0{\cdot}972$. For CS_2 the curve gives $v_m=0{\cdot}0046$ and experiment $0{\cdot}0031$. In spite of enormous variations of v_m, the theoretical numbers are of the same order of magnitude as the experimental ones. It is clear that the molecular weight of liquids can be calculated to within a few per cent. E. E. F.

LIGHT.

542. *Recorder of Photometric Readings.* **C. P. Mathews.** (Phys. Rev. 7. pp. 239–241, 1898.)—In taking photometric readings it is generally necessary to use some sort of illumination for the scale. This illumination is objectionable, since the sudden influx of light produces in the observer fatigue of the retina and of the pupillary muscles, and there is a consequent loss of visual sensitiveness. Furthermore, when it is a question of the photometry of a fluctuating source, the delay and irregularity of the readings is a drawback.

To remedy these disadvantages the author has used a recording drum. A cylinder of wood 10 cm. in diameter and about 1·5 m. in length is mounted with its axis parallel to and somewhat below the top of the photometer bar. At the end of a spring, attached to the photometer carriage, a steel point projects downward nearly to the surface of the cylinder. A rod extends the length of the cylinder and carries at one end a pawl which engages the teeth of a ratchet-wheel at the cylinder end. The act of sharply depressing the rod advances the cylinder a certain angular amount and punctures the paper by means of the steel point. With this recording apparatus the observer is enabled to take a series of readings and examine them afterwards. W. G. R.

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543. *Source of Luminosity.* **H. Crew** and **O. H. Basquin.** (Amer. Acad. Proc. 33. pp. 337–349, 1898.)—The authors here describe experiments designed with the object of answering the question, "Is it possible by heat alone to obtain the characteristic visible spectrum of a gas?" The electric arc is taken as the source of heat; but to study the thermal effects alone the chemical and electrical effects in the arc have to be separated from the thermal.

An alternating current is used for the arc, and by means of a special rotating interrupter on the alternator shaft all the currents in one direction or the other can be cut off from the arc. During these intervals when no current is passing between the electrodes, the arc is examined photographically and spectroscopically, a disc with suitable holes in it being mounted on the dynamo shaft to serve as rotating shutter to expose the arc at any desired instant during the interruption or at any phase of the current. Calculation and experiment both show that $\frac{1}{1000}$ sec. after the break, self-inductive effects have ceased, so that the electrical effects are then eliminated from the arc.

Electrodes of iron, zinc, and magnesium are used in an atmosphere of hydrogen, to eliminate, if possible, the chemical effects. With iron electrodes a persistent luminosity is observed in the arc after the current is interrupted, this luminosity being greater in an atmosphere of oxygen than in one of hydrogen. As the jet of hydrogen escaping from the vessel containing the arc is found to burn with a white centre in the flame characteristic of carbon compounds, it is evident that, with the impure iron used, chemical effects are not eliminated. Using electrodes of pure zinc or pure magnesium no persistent luminosity is found. The only light that remains after interruption, apart from that emitted by the red-hot electrode, is a sort of blue haze—a blue glow which fills the whole vessel and is there all the time. This light appears to be exactly the same for all three metals, iron, zinc, and magnesium. It is too diffused and faint to be easily examined by the spectroscope.

In reply to the main question, the authors conclude that on heating metallic vapours to the temperature of the electric arc, they are unable to discover any characteristic spectrum after an interval of $\frac{1}{1000}$ sec. As the form of electrode is, however, favourable to rapid cooling of the vapours, the authors intend repeating the experiments with another form less conducive to the rapid diffusion of the heat. J. B. H.

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544. *Dispersion in a Vacuum.* **L. Décombe.** (Comptes Rendus, 128. pp. 172–174, 1899.)—The author discusses the various astronomical methods available for detecting a possible dispersion in interstellar space, and shows that though the evidence is doubtful, it indicates a possibility of a greater velocity of the violet rays instead of the red. He proposes to make an experiment at two stations, say 9 km. apart, sending simultaneous optical and electromagnetic waves from one station and photographing them at the other by means of a rotating mirror, after converting the invisible wave into a spark or some other visible effect. He maintains that even a very slight retardation could be detected in this manner, and intends to carry out himself the experiment suggested. E. E. F.

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545. *Magnetic Double Refraction.* **A. Cotton.** (Comptes Rendus, 128. pp. 294–297, 1899.)—A sodium flame is placed between the pole-pieces of an electromagnet, and is traversed by an intense beam of white light. A nicol is placed on each side of the flame in the path of the white light, and the two nicols are crossed, their principal planes making an angle of 45° with the magnetic lines of force. The light which reappears on magnetising the electromagnet is studied by means of a Rowland grating. The general rule is that for each of the new rays created by the magnetic field, the flame only absorbs those rays of the white light which it emits itself. If the flame is rich in sodium, each of the D rays becomes a wide doublet with diffuse external boundaries. The components of each doublet are so widely

separated that the distance between the D_2 components may, for instance, attain a quarter of the distance between the two rays. The new rays are also very broad. The author has specially studied the polarisation of the rays from flames rich in sodium by means of a quarter-wave plate. On turning the analyser into such a position as to extinguish an elliptic vibration in the direction of the plane of the incident beam, the continuous spectrum reappeared with the two D lines reversed and broadened. On making the field, the borders of the two rays took up an unsymmetrical aspect. On one side of D_2 there appeared a bright fringe followed by a dark one, while the other border became brighter. Hence the vibrations in the neighbourhood of the rays had become elliptical, right-handed on one side and left-handed on the other, the rule being that for all radiations more refrangible than one of the D lines the component perpendicular to the field was in advance with respect to the other. The inverse was observed to hold good for the less refrangible radiations. This double refraction is connected with the Zeeman effect, and is in accordance with Becquerel's explanation. The vibrations parallel and normal to the field have distinct maxima of absorption, and also distinct curves of anomalous absorption. The rotatory dispersion observed by Macaluso and Corbino is easily accounted for by considering the two inverse circular vibrations. E. E. F.

546. *Secondary Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 128. pp. 300–303, 1899.)—The bundle of transformed rays emitted by a body under the influence of Röntgen rays constitutes a mixture of various rays whose powers of penetration, inferior to those of the Röntgen rays which generate them, form a series which is the longer the more profoundly the original Röntgen rays are modified. The heavy metals especially emit very heterogeneous secondary beams. The more easily absorbed rays are absorbed by a few millimetres of the air itself. The author calls the secondary rays S-rays. He describes an interesting experiment made by laying a sensitive film upon a metallic plate exposed to Röntgen rays, and gently inclining the film with respect to the metal. The Röntgen rays, of course, produce a blackening which is uniform all over the film. But where the layer of air between film and metal is not thicker than 1 mm. the blackening is intensified by the action of the S-rays. Quite close to the edge of the film, however, where the thickness of air is not more than 0·1 mm., there is a distinct brightening. The author suspects here the presence of some S-rays capable, like ordinary light, of neutralising the photographic effect of Röntgen rays, and recalls Schumann's discovery of extreme ultra-violet rays of $0{\cdot}1\mu$ wave length, which also possess this property, and are absorbed by a layer of air 0·1 mm. thick. E. E. F.

547. *Transformation of Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 128. pp. 546–549, 1899.)—To determine the precise degree of transformation of secondary rays which enter an electroscope, the author employs the method of successive filtrations. The same plate of aluminium, mica, ebonite, or paraffin is first interposed in the path of the incident Röntgen rays and then in the path of the secondary rays. The action of the secondary rays is feebler in the second case, and the time t' necessary for the same displacement of the gold leaf is longer than the time t required in the first case. The co-efficient $c=\frac{t'}{t}-1$ is called the co-efficient of transformation of the rays received by the electroscope. This coefficient varies with the thickness of air traversed, owing to the heterogeneous character of the ordinary Röntgen ray beam. On diminishing the thickness of air a limiting value of the coefficient is reached. The secondary rays emitted by the different metals then show transformation coefficients roughly increasing with the density or the atomic weight. E. E. F.

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548. *Dark Light.* **G. le Bon.** (Comptes Rendus, 128. pp. 297–300, 1899.)—Having proved that bodies exposed for only a few seconds to sunlight retain for several months the power of producing an impression upon a sensitive plate, the author goes on to show that bodies enclosed in opaque boxes can be photographed in a few seconds by using, in the place of a sensitive plate, a plate of phosphorescent zinc sulphide. After exposure, this plate is put into contact with a photographic plate, which is then developed by the usual methods. The source of light is a lamp screened by black paper, which acts the part of a Röntgen tube when the object is photographed by transmission But the object can also be photographed in its box by reflection, as in the case of ordinary light. To render the sulphide screen sensitive, it is exposed for a few seconds to sunlight. It is well known that the rays at the red end of the spectrum have the property of neutralising the phosphorescence produced by the more refrangible rays, and it is just the infra-red rays of a wave length of about 1·5 μ that are most capable of traversing opaque non-conductors such as ebonite, paper, and wood. In studying the physiological effects of the infra-red rays, the ordinary light rays, which neutralise them, will have to be eliminated. This could be done by covering a conservatory with black paper. All the objects inside would be exposed to a kind of invisible but exceedingly active light. E. E. F.

549. *Source of Uranium Radiation.* **W. Crookes.** (Comptes Rendus, 128. pp. 176–178, 1899.)—The anomaly in the radiation from uranium, thorium, polonium, and radium, the source of which has not yet been discovered, may be elucidated by assuming that these metals have the power of Maxwell's "demon" in being able to separate the rapidly moving from the slow-moving molecules of air, appropriating some of the energy of the former. The energy thus gained seems to be employed partly in dissociating some of the gaseous molecules, and partly in maintaining a radiation across the ether. The necessary smallness and small amplitude of these waves would make them similar in many respects to Röntgen radiation. The air round the Becquerel substance would of course be cooled, but more air would be constantly taking its place. Under ordinary circumstances the cooling is not detected, and the energy of the radiation appears to be created out of nothing. The total energy of the molecules of air in repose at ordinary pressure and temperature is about 180,000 foot-pounds per cubic metre of air. Hence the air contained in a room 4 × 8 × 7 m. possesses sufficient energy to give one H.P. for fifteen hours. E. E. F.

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550. *Residual Luminescence.* **G. le Bon.** (Comptes Rendus, 128. pp. 174–176, 1899.)—Most bodies exposed to light retain the property of emitting obscure radiation, sometimes long after the influence of the light has ceased. The phenomenon is best studied in those bodies which show luminescence under ordinary circumstances. Fifteen days after exposure to sunlight, screens of calcium sulphide are capable of giving sharp prints of negatives with an exposure of twelve hours. The residual luminescence produced by a few seconds' exposure to sunlight requires about eighteen months for its complete dissipation. The author proves, by photographing a statue painted with a luminescent substance by its own obscure radiation, that these obscure rays undergo refraction just like ordinary light. They are also polarised in the same manner. They behave, in fact, exactly as if they were rays of ordinary light, too feeble to make any impression upon the retina. E. E. F.

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551. *Phosphorescence at Low Temperatures.* **A.** and **L. Lumière.** (Comptes Rendus, 128. pp. 549–552, 1899.)—Attempts were made to determine the precise low temperature at which phosphorescent bodies lose their luminosity, to regain it on heating. Specimens of calcium and zinc sulphides exposed to the arc lamp showed an enfeeblement at −20° or −30°, and their phosphorescence disappeared entirely at about −50°. When exposed to magnesium light, the luminosity disappeared

between − 70° and − 90°. When exposure to magnesium light is made at − 191°, the temperature of liquid air, and the body is then heated, luminosity begins to appear already at − 180°, and increases as the heating proceeds. The exciting and emitting processes are thus separated, and by means of rapid heating, it is possible to watch the first stages of phosphorescence, which are usually masked by the incident light. This is specially valuable in bodies whose phosphorescence is of short duration. The neutralising action of the less refrangible rays is the same at low temperatures as at ordinary ones. Röntgen rays act like ordinary light, the phosphorescence produced by them setting in when the body is heated.

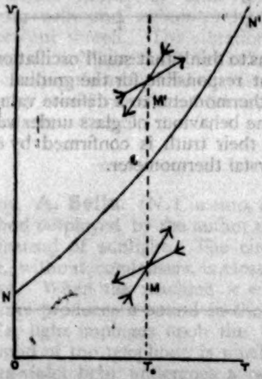
E. E. F.

552. *Phosphorescence of Strontium Sulphide.* **J. R. Mourelo.** (Comptes Rendus, 128. pp. 557–559, 1899.)—The same sulphide of strontium, obtained by Verneuil's method, will exhibit a brighter and more persistent phosphorescence after exposure to diffused daylight than after exposure to direct sunlight. Repeated short exposures to diffused light also increase the susceptibility of the substance, while repeated exposures to sunlight as a rule diminish it. Iron, heated to a temperature below red heat, is capable of exciting vivid phosphorescence, especially if the powdered substance is placed directly upon it. One phosphorescent substance is capable of exciting another. The author attempts to connect some of his results with Le Bon's "dark light." E. E. F.

HEAT.

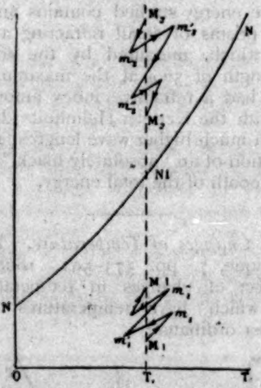
553. *Long Heat-Waves.* **H. Rubens** and **E. Aschkinass.** (Wied. Annalen, 67. 2. pp. 459–466, 1899.)—While quartz in layers a few mm. thick absorbs all heat rays from $\lambda=4{\cdot}5\,\mu$ to $\lambda=24{\cdot}4\,\mu$, the residual rays obtained by successive reflection from rock-salt ($\lambda=51{\cdot}2\,\mu$) and sylvine ($\lambda=61{\cdot}6\,\mu$) are again transmitted to a considerable extent, but they then show an extreme refrangibility, the index being as high as 2·46 for $\lambda=51{\cdot}2\,\mu$. Hence a quartz prism furnishes a simple means of separating out these rays from a miscellaneous spectrum, and a plate of rock-salt, which absorbs all heat rays, may be employed to test whether the energy studied contains any such rays. By means of quartz prisms of small refracting angles the authors obtained waves which, measured by the diffraction grating, showed a wave-length of $56\,\mu$ at the maximum of energy, and for which quartz had a refractive index amounting to 2·18, in close agreement with the Ketteler-Helmholtz dispersion formula. Attempts to obtain much higher wave lengths failed, owing to the fact that the radiation of an "absolutely black" body beyond $60\,\mu$ is less than 1/100,000th of the total energy. E. E. F.

554. *Glass and Changes of Temperature.* **M. L. Marchis.** (Journ. de Physique, 7. pp. 573–591, 1898.)—The author represents the effect of changes in temperature on glass by drawing curves which have temperatures as abscissæ, and specific volumes as ordinates:—



The curve for a rising is different from that for a falling temperature. At a given temperature when the specific volume is smaller than a certain amount, the ascending curve makes a greater angle with the horizontal than the descending; whilst the reverse holds for larger volumes. Thus the regions which behave differently are separated by a line which the author calls the line of natural conditions (*ligne des états naturels*). This line is represented in the above figure by NN′. M represents a condition when the specific volume at a temperature T_0 is less than the natural or stable volume; whilst M′ represents a condition when the volume is greater.

The figure below shows the effect of small oscillations in temperature. It will be noticed that below the line their effect is to increase the volume; whilst above, the volume is decreased.



The author seems to think that small oscillations in temperature are to a large extent responsible for the gradual approach of the reading of a glass thermometer to a definite value. By means of additional curves the behaviour of glass under various conditions is elucidated; and their truth is confirmed by experiments on a Guilbert-Martin crystal thermometer. A. Gs.

SOUND.

555. *Velocity of Sound in Air.* **J. Violle.** (Comptes Rendus, 127. pp. 904–908, 1898.)—A discussion of the corrections which must be applied to the experimental value obtained for the velocity of sound on account of the humidity of the air, taking into consideration the different ratios of the two specific heats in the cases of dry air and of water vapour. The author considers Leduc's criticism of the result obtained by himself and Vautier at Grenoble in 1885. J. J. S.

556. *Loudness of Phonograph.* **Dussaud.** (Comptes Rendus, 128. pp. 552–553, 1899.)—The sound reproduced by a phonograph is louder in proportion to the length of the furrow corresponding to each vibration. It follows that the loudness may be increased either by turning the record cylinder more rapidly while taking a record, or by constructing phonographs with wider cylinders. Further, if one phonograph is made to speak into another moving at a greater rate, or having a larger cylinder, the original sound will be amplified, and this can be carried to any desired extent. E. E. F.

557. *Radiophony.* **Dussaud.** (Comptes Rendus, 128. p. 171, 1899.) — For the sunlight used in the ordinary selenium cell arrangement the author substitutes ultra-violet light, but he retains the selenium cell, and influences it through the intermediary of a fluorescent screen. The vibrations are imparted to the beam by fixing an additional slit behind the slit in front of the arc lamp, and making the additional slit vibrate at right angles to its length with the sound vibration. Sounds have thus been transmitted to a distance of 10 m. E. E. F.

558. *Radiophony.* **A. Sella.** (N. Cimento, 8. 4. pp. 261–264, 1898.)—The method employed by the author involves the use of ultra-violet light instead of sunlight. The circuit of a powerful influence machine, without condensers, is closed by a telephone and a short air-gap. When the machine is working, the rapid succession of sparks produces a sound in the telephone. If a beam of ultra-violet light impinges upon the negative terminal of the gap the sound of the telephone is much altered. If the impact of the ultra-violet light undergoes a periodical variation the sound in the telephone will show an alternation of the same period, and if these periodical variations are short enough

combination tones are produced corresponding to the periodical disturbances of the ultra-violet light. On this principle the author constructs an instrument for transmitting sound to a distance. The ultra-violet beam is periodically deflected out of the way by means of a phonautograph mirror, and is finally received upon the flat kathode at the distant station. Greater clearness is obtained by putting the spark-gap in circuit with the secondary of an induction coil, and the telephone itself in the primary. The sound is also heard on putting the ear near the collectors of the influence machine. E. E. F.

559. *Telephone Experiment.* **A. Sella.** (N. Cimento, 8. 4. pp. 261–263, 1898.)—A telephone in circuit with a spark discharge gives a sound: let ultra-violet light fall on the negative terminal of the spark-gap and the sound is altered. If the ultra-violet light fall periodically a new sound is produced, of the same frequency as the interruptions. The ultra-violet light may be rendered intermittent on the spark-gap by being reflected from a vibrating membrane. The telephone may be put in circuit with the primary coil of an induction coil, the static machine and spark-gap with the secondary; the sound is then very loud and clear. A. D.

560. *Electrical Transmission of Sound.* **Dussaud.** (Comptes Rendus, 127. pp. 960–961, 1898.)—An invariable note is produced by means of an electrically controlled tuning-fork vibrating in front of a very sensitive microphone. This microphone transmits the note by means of an electric current to a telephonic receiver of new type, including four magnet-poles each acting on a membrane of iron. The air acted upon by the membranes is led into a small resonator of the form and size of the human mouth. Musical sounds and the spoken voice have been transmitted over some distance and made audible throughout a large hall. J. J. S.

ELECTRICITY.

561. *Energy of the Magnetic Field.* **H. Pellat.** (Journ. de Physique, 7. pp. 702–708, 1898.)—Referring to his former paper (Comptes Rendus, 125. p. 699, 1897), in which he had proved that the usual expression for the energy of an electric field requires modification if the temperature is to be constant, M. Pellat now proves the same result for the magnetic field. He considers three cases—(1) in which are concerned only natural magnets; (2) only electromagnets; (3) both. For case 1, all the magnets are assumed to increase in intensity *pari passu.* If U_T be the energy that has to be provided to increase all the magnets from zero to x and maintain the temperature constant, he finds

$$dU_T=\left[\Sigma MV-T\left(\frac{d\Sigma MV}{dT}\right)\frac{x}{M}\right]dx$$

in which V is the magnetic potential, Mx the magnetic charge.

In case 2, the currents all increasing *pari passu*, from zero to x, he finds

$$U_T=\frac{1}{2}\Sigma\left(L-T\frac{dL}{dT}\right)I^2+\Sigma\left(M_{ij}-T\frac{dM_{ij}}{dT}\right)I_iI_j$$

where $\frac{1}{2}L_1I^2_1+MI_1I_2+L_2I^2_2$ is the usual expression for the energy of two circuits, and ΣL is the sum of all the L's, ΣM_{ij} is the sum of the M's for every pair of circuits.

In case 3, M. Pellat finds that the energy of a field consisting of electric circuits and natural magnets is the energy of the electric circuits in the absence of the magnets plus the energy of the magnets in the absence of the circuits, as Kelvin pointed out many years ago (see also 1899, Abstract No. 318). S. H. B.

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562. *Loss of Electric Charge by Evaporation.* **H. Pellat.** (Comptes Rendus, 128. pp. 169–171, 1899.)—A definite proof is furnished that electrified water loses part of its charge by evaporation. The author studied the loss of charge from a system comprising a very flat dish, either empty or full of water, and a quadrant electrometer. The charge was imparted by a battery giving 116 volts. Without water, the loss amounted to 170·4 scale divisions in 105 minutes. With water it was 182·9 divisions in the same time. The twenty experiments gave very concordant results. The author applies them to explain the daily variation of atmospheric electricity after sunrise and sunset, but admits that the maximum at 8 p.m. and the minimum at 4 a.m. are not explained yet. E. E. F.

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563. *Electrical Discharges.* **J. Trowbridge.** (Amer. Acad. Proc. 33. pp. 435–452, 1898.)—The author gives an account of his experiments in which air and other gases are subjected to powerful electrostatic stress (see also 1899, Abstract No. 281.) The additional points which may be noted in the present paper are the following conclusions of the author:—

1. When the initial resistance of highly rarefied air is broken down by means of Röntgen rays, it exhibits less resistance than it does at 2 mm. pressure, when it is generally considered to have the maximum conductivity.

2. There are anode Röntgen rays as well as kathode Röntgen rays, and these rays exhibit all the peculiarities of the kathode rays; such as the excitation of fluorescence, and the peculiar action of breaking down the initial resistance of air and other gases.

3. Röntgen rays can be distinctly produced with an E.M.F. of 10,000 volts, and there are indications of them at a pressure of 5,000.

4. Electrostatic induction is an important phenomenon in that of Röntgen rays, the mechanism of their production being a setting up of electrostatic lines of induction along which the E.M.F. acts, and the production of an electromagnetic wave or impulse. The stress in the medium reduces its initial resistance, and the Röntgen rays' radiation becomes less and less energetic after a certain interval the longer the Crookes tube is excited, for the increased conductivity of the medium persists after each impulse of such radiation, and therefore the difference of potential between the terminals speedily drops, or docs not rise to the full value which the induction machine is capable of developing.

5. The behaviour of highly rarefied media to powerful electric stress is analogous to that of elastic solids to mechanical stresses. The generation of Röntgen rays is accompanied by a powerful electrostatic stress which breaks down the so-called elasticity of the medium. J. J. S.

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564. *Continuity of Vacuum Discharges.* **M. Cantor.** (Wied. Annalen, 67. 2. pp. 481–484, 1899.)—Under certain conditions, vacuum discharges can be obtained which are apparently continuous. But their apparent continuity may be due to the fact that the instruments employed are not sufficiently sensitive to discover any discontinuity. The author has, therefore, tested the matter with the aid of the coherer. He placed a battery of 1,000 accumulators in the cellar, and connected it by thick copper wires with the laboratory on the second floor. On joining the kathode of the vacuum tube with the leaves of an electroscope, and through a liquid resistance with its metallic case, the form of discharge described by Hertz was found to be apparently continuous, since the electroscope showed no divergence. But,

under the same circumstances, a coherer filled with small iron screws showed the presence of waves distinctly. A number of controlling experiments, undertaken to eliminate sources of error, led to the same result. It remains now to discover whether the wave system is superimposed upon a continuous substratum, or whether the discharge is entirely discontinuous. E. E. F.

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565. *Anode Rays.* **A. Broca.** (Comptes Rendus, 128. pp. 356–358, 1899.)—The author mounts two pointed electrodes of platinum, 2 mm. thick, in the centre of a spherical vacuum bulb, and surrounds the stems of the electrodes with glass tubes. The distance between the points is only half a millimetre. With a sparking distance in air of about 12 cm., a very small and very brilliant spark is obtained at every discharge. After some time, a small crater is formed in the anode, resembling the crater formed in a positive carbon. This distinctly proves the discharge of some material particles, and thus furnishes another proof of the emission theory. Ordinarily, whatever material disintegration there is is found in the kathode. But that is simply due to the fact that in the ordinary tubes the potential gradient is steepest at the kathode. In the spherical tubes described the potential gradient is uniform, and the metal, being electropositive, naturally escapes from the anode. That it is projected with considerable force is shown by the fact that no metal is deposited on the kathode, but that it goes to the glass wall. When the bulb is introduced into a magnetic field, the "anode rays" are deflected in a sense opposed to the deflection of kathode rays. They also show a left-handed screw motion where the kathode rays show a right-handed twist. E. E. F.

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566. *Canal Rays.* **A. Wehnelt.** (Wied. Annalen, 67. 2. pp. 421–426, 1899.)—When a cross of mica, fastened to a small piece of sheet-iron, so as to shift it with a magnet from outside, is placed within the dark kathode space of a vacuum tube, a shadow of the cross, somewhat hazy and magnified, appears on the kathode. The size of the shadow is independent of the distance between the cross and the kathode, as long as the cross remains within the dark space. The shadow is equally unaffected by a change of pressure, or the substitution of a cross of different material. It is evidently produced by the stoppage of positive particles moving towards the kathode, and these same particles, when they penetrate gaps in the kathode, give rise to the so-called canal rays. The canal rays are probably identical with the luminous layer which immediately adjoins the kathode. The positive or anode rays produce oxidation, and the author has succeeded in forming a permanent silhouette of the cross upon a

copper kathode in the usual colours of oxidised copper, the succession of tints at the half-shadows being the same as that seen on a copper plate unequally heated. E. E. F.

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567. *New Wave Detector.* **A. Neugschwender.** (Wied. Annalen, 67. 2. pp. 430–432, 1899.)—A narrow gap is scratched into the coating of a silver-on-glass mirror, and the mirror is inserted into the circuit of a Daniell cell and a galvanometer. On breathing upon the mirror, the condensed vapour bridges over the gap, and the galvanometer shows a deflection. But this deflection is immediately annulled when electric waves impinge upon the mirror. When a piece of moistened cloth is fixed near the mirror, the action is rendered continuous. Every train of waves produces an infinite increase of resistance while it lasts, and on its cessation the normal current is re-established. The gap in the mirror must be so wide, of course, that no ordinary coherer action intervenes. A good width is 0.3 mm. The experiment also succeeds with copper or tin as a mirror metal (though not with platinum), and with glass, mica, celluloid, caoutchouc, stearine, or pitch as a support. Ammonia, HCl, and various salt solutions may be employed, but no effect is produced unless the liquid is so far evaporated that nothing can be seen of it with the naked eye. Sound vibrations, concussions, statical charges and simple heating are without effect, but every spark discharge is instantly responded to. The response is so rapid that the individual discharges of an induction coil are separately indicated, as may be proved by inserting a telephone in the detector circuit. E. E. F.

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568. *Measurement of Electric Waves and their Absorption by Water.* **A. D. Cole.** (Phys. Rev. 7. pp. 225–230, 1898.)—These experiments were devised in order to determine the absorbing power of water for electrical radiations of wave-length ranging round 10 cm.

The liquid was placed in glass cells of different thicknesses and interposed in the path of the radiation so that its absorption might be observed. However, the observations were complicated by the fact that the path through the cell was comparable with the wave-length in the liquid, as was clearly shown by the results obtained. No attempt was made to deduce the absorption from the observations by means of the theory of thin plates of absorbing media. A thermo-junction was used in connection with the receiver, and worked satisfactorily. The radiator was a modified Righi exciter. F. T. T.

569. *Hertzian Field in Air and in Water.* **A. Turpain.** (Comptes Rendus, 127. pp. 955–957, 1898.)—With reference to his former experiments on air and oil (see C. R. 126. p. 1630, 1898), the author gives here the result of his measurements in the case of air and of water. He deduces the following experimental laws:—

1. The wave-lengths of the electric oscillations which excite a given resonator, placed in his "position II" are the same in air and in the dielectric.

2. For the oscillations which excite the resonator in the "position I," the ratio of the wave-length in air to the wave-length in a dielectric is equal to the square root of the specific inductive capacity of the dielectric.

The number obtained for this ratio in the case of air and water varies with different resonators from 7·0 to 8·5. J. J. S.

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570. *Electromagnetic Waves near Wires.* **A. Sommerfeld.** (Wied. Annalen, 67. 2. pp. 233–290, 1899.)—The author studies the propagation and distribution of a periodic and harmonic electrodynamic disturbance in the vicinity of an infinite straight wire. He finds that the differential equations for the electric and magnetic components inside and outside the wire are easily integrated, and lead to Bessel functions. On excluding the possibility of a propagation exceeding the velocity of light, and unaccompanied by damping—a possibility which would suppose an unknown radial supply of energy from infinity—the surface conditions furnish a transcendental equation whose root determines the wave-length λ and also the speed of propagation λ/τ of the wire wave, as well as the constant of local damping κ in the complex formula $(2\pi/\lambda)-i\kappa$. The discussion of this transcendental equation makes it necessary to distinguish two chief cases, accordingly as the number ρk is large or small. The number ρk is defined by $k=2\pi\sqrt{C\mu/\tau}$, where C is the conductivity in electromagnetic measure, μ the constant of magnetisation, τ the duration of oscillation, and ρ the radius of the wire. The number is usually large for metallic conductors, especially if the oscillation is not too slow nor the wire too thin. In both cases the very complex original equation may be much simplified by a rapidly convergent solution. In the case of a large ρk the solution corresponds with the generally accepted views of the nature of wire waves. The divergence of the propagation from the velocity of light is very small, and so is the damping of the wave in its progress along the wire, and it is the smaller the larger the value of ρk. Thus in the case of a copper wire 4 mm. thick and a frequency of 10^9 per second it appears that the wire wave lags behind light only by about 8 km. per second, and is damped to the eth part of its value only after covering 1·5 km. of its path. But in the second case the deviation from the velocity

of light and the damping may be very considerable. Thus in a platinum wire 0·004 mm. in diameter and with a frequency of 3×10^8 per second the speed is only three-quarters of the rate of propagation of light, and the damping is so strong that it reduces the amplitude to its *e*th part within a distance of only 17 cm.

There is, of course, a continuous transition between cases 1 and 2. The distribution of the electric and magnetic forces in the two cases agrees with the current views in case 1, and disagrees with them in case 2. In case 1 the forces diminish rapidly from the surface inwards. The whole process, in so far as it has not descended below the hundredth part of the surface intensity, is confined to a layer of the thickness $4{\cdot}6/k$, *i.e.*, in the copper wire mentioned, in a layer of thickness less than 0·01 mm. Outwards, the forces diminish rather slowly. In the interior, the electric lines of force are nearly tangential; outside they are nearly normal to the wire surface. But in case 2, owing to the thinness of the wire, the surface layer cannot freely develop itself. Outside the wire, the lines of force are not even approximately normal to its surface.

The author proceeds to point out what outstanding questions remain to be answered.

In the first place, while the present investigation deals with a single infinite wire without return circuit, the practical arrangement used consists of two parallel wires joined by a bridge. It is probably very difficult to determine mathematically the effect of this device upon propagation and damping. The nearest approximation to the actual case would probably be obtained by ascribing a parabolic curvature to the infinite wire. Then we should have either a single wire or two parallel wires according to the size of the parameter of the parabola.

The position of the source of the waves, a free end of the wire, or a resonator introduced into the field would produce disturbances not considered in the author's theory. Also, instead of a periodic harmonic disturbance, the generation of a steady electric current may have to be contemplated. Liquid conductors would also create new conditions, but the present theory would apply to wires surrounded by a dielectric different from air. E. E. F.

571. *Dielectric Constant of Stretched Indiarubber.* **O. M. Corbino** and **F. Cannizzo.** (Roma R. Accad. Lincei. Atti, 7. pp. 286–292, 1898.)—A sheet of red caoutchouc, under varying degrees of tension, forms the dielectric of a condenser the capacity of which is compared with a second condenser whose capacity can be varied at will. A special determination shows that Poisson's ratio equals 0·42; and after applying corrections, the authors find that the dielectric constant diminishes with increase of tension. The way in which its value varies, within the limits examined, is indicated by the equation $\kappa' = \kappa\,(1 - \mathrm{A}\lambda)$; where κ is the

dielectric constant when the caoutchouc is free from load, and κ' is the dielectric constant when the elongation per unit length is λ. Also $A = 0{\cdot}64\ (\kappa - 1)$. A. Gs.

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572. *Dielectric Strength.* **T. Gray.** (Phys. Rev. 7. pp. 199–209, 1898.)—Circular transformers giving 100,000 volts were used with a choking coil to prevent short circuits. The pressure was inferred from a Kelvin voltmeter on the primary. The terminals were polished spherical surfaces of 35 cms. radius.

It was assumed that the effect of a thick continuous dielectric could be obtained by superimposing several sheets. The following results were obtained :—

Material.	Maximum Dielectric Strength in Kilovolts per centimetre.
Glass	285
Hard rubber	538
Soft rubber	476
Soft rubber, second quality	492
Mica	2000
Micanite	4000
Papers paraffined :	
Manilla wrapping	430
American linen	540
Blotting felt	150
Fuller braid	295
Empire cloth	310
Empire paper	450
Lubricating oil	48
Linseed oil	83
Cotton seed oil	67
Air, 0·02 cm. between plates	57
Air, 1·6 cms. between plates	27

M. O'G.

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573. *Electrical Properties of Vapours from the Carbon Arc.* **E. Merritt** and **O. M. Stewart.** (Phys. Rev. 7. pp. 129–148, 1898.)—The vapours from a carbon electric arc are conveyed to a charged brass cylinder, and its rate of loss of charge measured by means of a quadrant electrometer. The results of the experiments are :—

1. The vapours from the carbon arc possess the power of discharging electrified bodies with which they are brought into contact. In general the electrical properties of these vapours are similar to those of gases that have been acted on by Röntgen rays, or to gases from a flame. Except at low potentials the rate of discharge is not proportional to the potential, but approaches a limiting value as the potential of the charged body is raised.

2. This discharging power is retained even after the vapours have been passed through long tubes of glass or metal, and lasts for at least ten seconds.

3. When caused to pass between a charged conductor and one that is earthed, the vapours lose most of their conducting power. A similar result is obtained by passing the vapours through loosely packed asbestos wool.

4. After passing between two earthed conductors only a short distance apart, the vapours are found to discharge a negatively electrified body more rapidly than one charged positively. In this respect their behaviour is similar to that of gases that have been ionised by the action of Röntgen rays. The explanation is probably that suggested by Zeleny, viz., that the negative ions diffuse more rapidly than the positive ones.

5. Positive and negative charges are in general dissipated by the vapours with equal rapidity. Experiments made with a vertical enclosed arc, however, show that gases taken from near the lower carbon have unequal discharging powers for the two electricities; in this case the charge which is of the same sign as the lower carbon is dissipated less rapidly. This is true whether the lower carbon is positive or negative; and the effect is not altered by connecting either carbon to earth.

6. If air or oxygen that has been saturated with water vapour is introduced into the enclosure containing the arc, the conducting power of the arc vapours is greatly increased. This effect, however, can no longer be observed when the body to be discharged is at a considerable distance from the arc. E. C. R.

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574. *Electric Conductivity and Luminosity of Flames.* **A. Smithells, H. M. Dawson, and H. A. Wilson.** (Roy. Soc. Proc. 64. pp. 142–148, 1898.)—No general consensus of opinion appears to exist as to the mode by which the metal of an alkali salt is liberated when the salt is vaporised in a flame. By some the liberation is supposed to be effected thermally by chemical dissociation; others suppose that the salt is converted into hydrate or oxide, and then reduced by the flame gases. It is also noteworthy that however the metal be liberated and however oxidisable it may be, light is emitted from parts of the flame where oxidising gases are in abundance, and where even less oxidisable metals in the massive state are rapidly oxidised. The objects of the experiments described is to ascertain whether the luminosity imparted by vaporised salts to flames is related in a definite manner to the electrical conductivity of the salt vapours. The apparatus employed is essentially the arrangement used by one of the authors (Smithells, Phil. Mag. 39. p. 122, 1895) in other investigations of flame, whereby the two cones that constitute the flame of a Bunsen burner can be separated widely and

maintained apart for any length of time. The authors conclude from their experiments:—

1. That the conductivity of vaporised salt is of an electrolytic character, but that there are features connected with it that distinguish it from electrolytic conduction in aqueous solution. Thus Ohm's law is only obeyed within certain limits, and the general relation between current strength and electromotive force can only be represented generally by a more complex expression.

2. The conductivities of different salts differ greatly according to the electropositive constituent.

3. Among different salts of the same metal differences of conductivity appear at the higher concentrations, but at low concentrations equivalent solutions have equal conductivity.

4. The conductivity of the haloid salts as a group is distinct from that of the oxy-salts.

5. The conductivity of the haloid salts of a metal among themselves increases with the increasing atomic weight of the halogen.

6. The conductivity of the oxy-salts of a metal is approximately equal to and approaches, that of the hydrates.

7. The more easily oxidisable halogen salts are probably partly converted into oxide in the flame, so that their conductivity is composed of two parts.

8. The behaviour of the salts in flames supplied with chloroform vapour seems to establish the fact that the conductivity and the colour produced by the salt vapour are not due to a common cause. J. J. S.

575. *Thomson Effect in Copper.* **R. O. King.** (Amer. Acad. Proc. 33. pp. 353–379, 1898.)—The object of this investigation was the determination of the Thomson Effect in copper in absolute measure and its variation with temperature.

The copper bar experimented with was heated by an electric current, while its two ends were kept at a constant temperature by water circulation. A descending temperature gradient and consequent flow of heat were therefore established from the centre of the bar towards both ends. Owing to the electric current being against the flow of heat in one half of the bar, and with it in the other, the temperature of one half of the bar gained at the expense of the other, due to the Thomson effect. By reversing the current and measuring the rise or fall of temperature at different points along the bar, the Thomson effect was calculated from the data obtained.

The temperature distribution along the bar was determined by measuring (by a potentiometer method) the electrical resistances of successive short lengths of the bar when heated, the resistances of these same sections at ordinary temperatures and the temperature coefficient being known. Separate experiments were made with the bar heated by different currents to determine the heat lost by radiation and convection from the different sections of the bar. The heat lost from a section by conduction could be calculated from the conductivity and the temperature gradients at its ends.

The results of one set of experiments are:—

$\theta=166^\circ$ C. $\sigma=608\times10^{-8}$ Calories per sec.
$\theta=183^\circ$ C. $\sigma=606\times$ „ „ „ „
$\theta=197^\circ$ $\sigma=566\times$ „ „ „ „
$\theta=208^\circ$ $\sigma=508\times$ „ „ „ „

The results show a diminution of the Thomson effect with increase of temperature, and are therefore not in accordance with Tait's assumption that it is proportional to the absolute temperature. It is therefore inadvisable to deduce values of the Thomson effect for other metals in the customary way. J. B. H.

576. *Measurement of High Resistances.* **J. Schürr.** (Journ. de Physique, 7. pp. 598–602, 1898.)—The method consists in determining the damping of the oscillations of a d'Arsonval galvanometer when on open circuit and when shortcircuited by the unknown resistance. Resistances varying from 4,800 to 800,000 ohms are measured with an accuracy of about 1 per cent. Specific resistances of electrolytes are also determined by this method. J. B. H.

577. *Resistance of Moving Electrolytes.* **E. H. Hall.** (Phys. Rev. 7. pp. 246–247, 1898.)—In *Il Nuovo Cimento* for April, 1877, Bosi describes experiments which appear to show that a very moderate velocity of an electrolyte in the direction of, or contrary to, the direction of an electric current through it, makes a considerable change, increase or decrease, according to conditions, in the electrical resistance of the electrolyte.

Last year a student of the author's repeated this experiment in a slightly modified manner, and concludes that Bosi's conclusions are incorrect. W. G. R.

578. *Polarisation and Internal Resistance of Cells.* **K. E. Guthe.** (Phys. Rev. 7. pp. 193–198, 1898.)—The author investigates the apparent variation of internal resistance with generation of current in a primary cell, or passage of current in a voltameter. Wiedeburg's theory of polarisation is the one which

gives the best representation of the facts. His formula for the polarisation of a voltameter is as follows :—

$$p=\frac{P_1}{2}\left(1-e^{-\frac{\beta_1}{s_1}q}\right)+\frac{P_2}{2}\left(1-e^{-\frac{\beta_2}{s_2}q}\right)$$

in which P denotes a limiting value, β a constant, s_1, s_2 the surfaces of the electrodes, and q the quantity of electricity that has passed. This theory demands a curve for internal resistance decreasing with increasing currents; for if the experiments are carried out with equal intervals of time, the above gives rise to the following equation :—

$$\rho-r=\frac{P}{I}\left(1-e^{-KI}\right)$$

in which ρ is the apparent resistance, r the actual resistance, and I is the current. By using the pendulum apparatus previously used by Carhart for the determination of E.M.F. and potential difference on closed circuit (and thence the internal resistance), the author determines the value of ρ in a copper voltameter for various currents. These decrease with increasing current, as already shown by previous investigators; but the values of r, or the true internal resistance, deduced from these are constant.

W. R. C.

579. *Polarisation Capacities.* **A. M. Scott.** (Wied. Annalen, 67. 2. pp. 388–420, 1899.)—The author completes his researches on the polarisation of thin metallic membranes, and studies the influence of electrolytic polarisation upon apparent capacity, and the influence of pressure upon polarisation capacities. His results enable him to declare that all polarisation phenomena in thin gold membranes are due to pores in the metal, whose existence may be demonstrated. In the platinum membranes employed no pores could be found, and no depolarisation was provoked by an alternating current. The polarisation capacity of platinum, he concludes, is determined by occluded gases, and depends upon the condition of the platinum. Gold and aluminium show a similar behaviour under kathodic polarisation, and show an increase of capacity with E.M.F. Under anodic polarisation an insulating layer is produced on the aluminium, whereas gold goes slightly into solution at higher E.M.F.'s. The polarisation capacity of silver and lead is affected by the metallic ions in the electrolyte. The hydrogen ions have no appreciable influence. Under kathodic polarisation, mercury has a minimum polarisation capacity at an E.M.F. corresponding to the difference of potential between the mercury and the electrolyte, but solutions showing an abnormal behaviour as regards

maximum surface tension also show abnormal results with regard to minimum polarisation capacity. External pressure has no influence upon polarisation capacity. E. E. F.

580. *Polarisation of thin Metallic Foil.* **G. P. Grimaldi** and **G. Platania.** (Atti del Acc. Givenia de Catane, 10. 4, 1897, and Écl. Électr. 17. pp. 211–214, 1898.)—The polarisation of thin sheets and of foil is studied by means of a pendulum charger and discharger. The time of charging is obtained from the length of the pendulum. The sheets of polished gold have a thickness of 0·09 mm. The gold foil has a thickness of 10^{-4} mm. Equal areas are exposed. The following table gives the mean results for a great number of experiments.

Time in Seconds.	E.M.F. of Polarisation.		Ratio of Sheet to Foil.
	Sheet.	Foil.	
0·0022	0·045	0·033	1·36
0·0047	0·084	0·068	1·23
0·011	0·170	0·139	1·22
0·021	0·260	0·224	1·16
0·054	0·434	0·377	1·14
0·147	0·546	0·526	1·03
0·295	0·606	0·605	1

S. S.

581. *Temperature Coefficient of the Potential of the Calomel Electrode.* **T. W. Richards.** (Zeitschr. Phys. Chem. 24. pp. 39–54, 1897, and Amer. Acad. Proc. 33. pp. 3–20, 1897.)—The calomel electrodes are united by various supernatant electrolytes, so as to form systems of the general form Hg—HgCl—MCl—HgCl—Hg. One calomel electrode is maintained at a low temperature, and the other warmed to various temperatures. The potentials are compensated on a Poggendorff potentiometer using either a sensitive galvanometer, or a Lippmann capillary electrometer. The results of the experiments are:—

(*a*) The temperature-coefficient of the potential of the calomel electrode increases with the dilution of the electrolyte.

(*b*) The kation of the electrolyte influences the result by affecting the degree of ionisation of the chloride in solution.

(*c*) Both these effects may be approximately computed by a simple logarithmic formula based on Nernst's hypothesis.

(*d*) The accuracy of the results is affected by the catalytic decomposition of mercurous chloride into mercuric chloride and mercury.

(*e*) This decomposition is responsible for the slight inconstancy of the normal calomel electrode.

(*f*) The "decinormal" electrode is more constant than the normal.

(*g*) HCl and NH_4Cl are anomalous in their behaviour.

S. S.

582. *E.M.F. of Clark and Cadmium Cells.* **S. N. Taylor.** (Phys. Rev. 7. pp. 149–170, 1898.)—The author finds that cadmium cells are as easy to construct as Clark cells, and arrives at the result that

$$\frac{\text{Clark cell at } 15^\circ}{\text{Cadium cell at } 21{\cdot}7^\circ} = 1{\cdot}4077.$$

Absolute measurements were also made, by means of a dynamometer, of the E.M.F. of the Clark, but the results appear to be of no value. W. R. C.

583. *Jacques Cell.* **J. W. Langley.** (Frank. Instit. Journ. 146. pp. 224–234, 1898).—The author gives curves showing the variation of E.M.F. with temperature. As the latter rises, the E.M.F. falls, and *vice versâ*. Experiments were carried out with copper and iron (with and without air blast) in place of the carbon, but the results were much the same as when carbon was used. Sodium nitrate around the carbon, in place of air, diminished the E.M.F. The author concludes in favour of a thermoelectric origin of the E.M.F. W. R. C.

584. *Electrolytic Contact Breaker.* **A. Wehnelt.** (Elektrotechn. Ztschr. 20, pp. 76–78, 1899.)—Starting from the well-known fact that a current passing through a liquid between two electrodes of very unequal area is capable of producing luminosity on the smaller electrode, and that these luminous effects show signs of intermittence, the author determined whether there was a true interruption of the current, or only a variation between a maximum and a minimum value. He inserted a lead plate and a platinum wire into a beaker filled with dilute sulphuric acid, the platinum electrodes being held by a glass tube filled with mercury, with its end bent towards the lead plate. He found that such a cell, with the wire as anode, acts as a very perfect interrupter with a frequency of about 1,000 per second, giving sparks 40 cm. long with 6 amperes and 12 volts. A condenser is superfluous, and there is no need to eliminate self-inductions. The latter indeed are, on the whole, beneficial. The interruptions occur with remarkable regularity, as indicated by the pitch of the note emitted. E. E. F.

585. *Electrolytic Contact Breaker.* **d'Arsonval.** (Comptes Rendus, 128. pp. 529–532, 1899.)—The author confirms all the results stated in the preceding abstract, and adds some valuable observations of his own. With 70 volts he obtained from an induction coil sparks in the shape of a continuous stream of fire 25 cm. long, and of the thickness of a pencil. The frequency, as determined by means of a revolving mirror, was 1,700 per second With a small coil of only 4 cm. spark length the frequency was over 3,000 per second. The frequency depends upon the self-induction of the coil, the size of the platinum wire, and the E.M.F. of the current. A wire 0·7 mm. thick, projecting about 2 cm. from the glass tube, gives good results. With such a wire the author excited a Crookes tube and obtained Röntgen rays of a steadiness and penetrating power far beyond the usual. A radiograph of the hand was instantaneous. Employed with one of the author's medical apparatus of high frequency, the new interrupter gave results at least ten times as strong as those obtained with the Foucault interrupter. When an alternating current is substituted for the continuous current, the coil works equally well, and, what is very important, it lights up the Crookes tube just as in the case of the continuous current, which proves that the interruptions take place in only one direction. The new interrupter is therefore also a current separator. Hence, in radiography, the same work can be done whether the current available is continuous or alternating.

In conjunction with a Berthelot effluviator, the coil gives quantities of ozone incomparably greater than the ordinary spring interrupter. Regular and powerful Hertzian waves may also be obtained, and wireless telegraphy is thereby greatly facilitated. The interruption curve, traced with an Abraham rheograph, is very regular, and shows no traces of parasitic oscillations or idle time. The best form of interrupter hitherto obtained consists of a test tube with the platinum wire introduced through the bottom. Potash may be substituted for the dilute acid, and iron for the lead. The following is the author's theory of what takes place: By the passage of the current the platinum point is brought to a white heat. Thereupon the liquid is heated, and forms a layer of non-conducting vapour round the platinum, thus interrupting the current. Then the vapour condenses, the current recommences, and the process repeats itself. This view is supported by the fact that when the liquid is hotter than 90° the vapour is no longer condensed, and the interrupter does not act. There is also an evolution of an explosive mixture of hydrogen and oxygen, due to the white-hot platinum. This also explains why the interruption takes place only in one sense; for when the platinum point is positive it heats up quicker than when it is negative. To fully utilise the valuable properties of the coherer, the induction coil will have to be modified as regards shape, dimensions, and nature of insulator. Since high frequencies are at work, it is better to have a liquid, or at least a pasty insulator. E. E. F.

586. *Electrostatic Voltmeter.* **A. Perot** and **C. Fabry.** (Journ. de Physique, 7. pp. 650–659, 1898.)—This voltmeter, which is designed as a standard, is of the attracted disc type. The suspended system consists of an equilateral triangular plate of glass silvered lightly on both sides. It is suspended between two equal fixed triangular plates of glass, these two plates being separated from each other by glass pieces at the three corners, the movable plate being turned through 60° in azimuth to clear the separating pieces. The surfaces of the fixed plates facing the movable plate are lightly silvered and the top plate is electrically connected with the movable one. A beam of white light is sent through the three plates, and if the thicknesses of the two air films differ little, the system of "interference fringes of superposition" is seen. By means of these fringes the position of the suspended plate can always be recognised and when attracted towards the bottom plate by a difference of potential between them it can always be brought back to the same zero position by extending the central spring which, together with three other springs, carries it. The amount of extension of this spring gives the attracting force, but as the difference of potential is proportional to the square root of the attraction, a mechanical system of links connects the end of the spring with a pointer, which moves a distance equal to the square root of the extension of the spring.

The instrument constructed had the top plate slightly convex on the silvered side to give a circular form to the fringes. It measured from 20 to 70 volts with an accuracy of 0·1 volt.

J. B. H.

587. *Combined Ammeter and Voltmeter by General Electric Company.* (Electrician, 41. pp. 677–679, 1898.)—This instrument is of the round dial form, and is primarily a galvanometer of the d'Arsonval type, having its coil pivoted and controlled by two springs, by means of which current is led into and out of the coil. Used as a galvanometer, a current of 0·00004 ampere is easily measured, so that with a constant potential of 200 volts, insulation resistance can be tested up to 5 megohms. Larger currents and also pressures are measured by using a shunt and series resistance. W. G. R.

588. *Condenser Losses.* **E. B. Rosa** and **A. W. Smith.** (Phys. Rev. 8. pp. 1–20, 1899.)—The enormous discrepancies between the results of measurements previously made with a view towards determining the numerical value of the energy lost in condensers led the authors to measure this energy loss in such a way that it could be expressed absolutely. They measure by means of a wattmeter the energy dissipated in a condenser when it is subjected to an alternating E.M.F. In order that the

frequency of charge and discharge be perfectly definite, the E.M.F. should be a simple harmonic one, that is, the upper harmonics of the fundamental should be absent. This is most easily effected by inserting in the circuit in series with the condenser a coil of wire having large self-induction but without an iron core. The variable permeability of the iron gives rise to upper harmonics, especially if the magnetic induction of the core attains larger values, and hence a coil without an iron core is necessary. The best value for the self-induction of the coil is such that the fundamental is reinforced to a maximum degree, in other words, it is the value of L given by the equation

$$t = 2 \pi \sqrt{LC}$$

There is another practical advantage resulting from this arrangement, namely, that the resulting resonance raises the E.M.F. at the terminals of the condenser very greatly, thus saving the necessity of raising the pressure by transformers. And a third advantage now appears in the fact that the wattmeter may be inserted across the low pressure supply wires to measure the total power expended upon coil and condenser. Then subtracting the I^2r loss of the coil, the remainder will be the power expended upon the condenser. This supposes, of course, that there is no iron core, and no eddy current loss in the copper coil itself. The

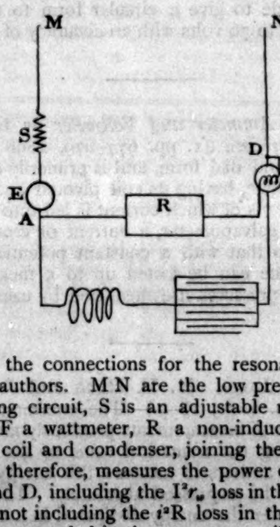

diagram shows the connections for the resonance method employed by the authors. M N are the low pressure supply wires of an alternating circuit, S is an adjustable resistance, E is a dynamometer, F a wattmeter, R a non-inductive resistance in shunt with the coil and condenser, joining the points A and D. The wattmeter, therefore, measures the power expended between the points A and D, including the I^2r_w loss in the fixed coil of the wattmeter, but not including the i^2R loss in the shunt resistance R. The energy expended in the resonance coil and the fixed coil of the wattmeter, subtracted from the total power measured, leaves the condenser loss. This remainder is found to be also proportioned to the square of the current. Hence we may write it I^2r_2, and r_2 is the "equivalent resistance" of the condenser, which it is desired to find. This does not indicate the nature of the process by which energy is dissipated in a condenser, but simply that for a given condenser made of a given dielectric, at a given temperature and frequency, the heating effect is the same as though there were a certain resistance r_2 in series with a perfect condenser of the same capacity.

Experiments with a tinfoil and paraffined paper condenser of 0·8 microfarad capacity, with a current of 1·2 amperes and a frequency of 145 gave 23·45 watts for the condenser loss, which is, however, rather too large on account of the eddy current loss in the resonance coil, although the latter had no iron core. Some extraordinary results were obtained with some commercial condensers of ⅓ microfarad, made with melted beeswax and resin. The loss in the condenser was as high as 26·5 watts at 30°. The loss at 36° C. was 50 per cent. greater than at 30°, and approached a maximum at that temperature. At 47° C. the loss had decreased from 9 to 8 per cent. of the total, and at 49·5° C. to 6·5 per cent. No further readings were taken until the condensers had risen several degrees, when it was suddenly noticed that one pair was hotter than the others, and getting soft. The loss was very large, but the condenser had not broken down, and the leakage current had not greatly increased. These observations were fully confirmed by a totally different method, which consisted in measuring the heating effect by a specially constructed calorimeter.

E. E. F.

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589. *Condenser Losses.* **E. B. Rosa** and **A. W. Smith.** (Phys. Rev. 8. pp. 79–94, 1899, and Phil. Mag. 47. pp. 232–236, 1899.)—The authors' resonance method of measuring the energy dissipated in condensers subjected to an alternating E.M.F. is not sufficiently delicate to give accurate values in the case of paraffined-paper condensers. The same authors have, therefore, constructed a special calorimeter for the purpose of measuring the total quantity of heat produced in the condensers. Tests made with a number of Stanley paraffined-paper condensers showed that they could easily stand 500 volts alternating E.M.F., as indicated by the makers; but that the loss of energy in the condensers could not be calculated, and varied in different specimens within wide limits. At a frequency of 140 per second, the smallest loss observed was 0·74 per cent. One lot of condensers gave a nearly uniform loss of 1·5 per cent., while another lot went as high as 10 per cent. on high frequencies. In beeswax-and-resin condensers the loss was 6 or 8 per cent. As in the experiments with the resonance method, the energy loss was found to be highest at 40° C., and that temperature also repre-

sented the maximum for residual charge. The authors maintain that the singing or hissing of a condenser is not connected in any way with its efficiency. E. E. F.

590. *Effects of Prolonged Heating on Magnetic Properties of Iron.* **S. R. Roget.** (Roy. Soc. Proc. 64. pp. 150–156, 1899.) (See 1898, Abstract No. 948.)—This paper contains an account of further experiments on this subject, the results being extended to temperatures up to 700° C. The baking was carried on in a specially constructed electric oven heated by coils of platinum wire wound on a mica frame. The temperature was read direct on a Callendar-Griffiths platinum pyrometer. The initial rise of hysteresis was found to be more rapid, the subsequent fall to take place sooner, and the final state to be one of lower hysteresis, the higher the temperature. Great differences of behaviour were observed among different specimens, and some of the brands examined were practically of non-ageing quality. The author sums up the chief effects of prolonged heating on the magnetic properties of iron thus:—

1. Material in the annealed state is more liable to change than in a harder state.

2. All the changes produced by prolonged heating are completely removed by reannealing.

3. The heating need not be continuous; the same cumulative effect is produced by a number of short periods at a given temperature as by continuous heating at the same temperature.

4. The liability of the material to increase in hysteresis at moderate temperatures is not removed by prolonged heating at high temperatures.

5. The change is confined to the lower part of the B-H curve, the upper part remaining unaltered.

6. The effect is produced equally, whether the iron is or is not exposed to the air during heating. A. H.

591. *Standard Representation of the Magnetic Qualities of Iron.* **H. Kath.** (Elektrotechn. Ztschr. p. 407, 1898, also Écl. Électr. 17, pp. 69–70, 1898.)—The author considers that the magnetic qualities of any kind of iron are sufficiently represented by:—

(*a*) A magnetisation curve of virgin iron for strengths of the magnetising field, H, varying from O to 150 c.g.s. units, or for steel up to 300 c.g.s. units.

(*b*) A hysteresis curve for values of H between $H = +150$ and $H = -150$ c.g.s. units, or for steel between $H = \pm 300$ c.g.s. units.

The scales should be 1 mm. = 100 c.g.s. for B and 2 mm. = 1 c.g.s. for H. W. G. R.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

592. *High Vacua by Liquid Hydrogen, with their Spectroscopic Examination.* **J. Dewar.** (Roy. Soc. Proc. 64, 231–238, 1899.)—Calculating from Willard Gibbs' formulæ, at the temperature of boiling H (35° abs.), the vapour pressures in mm. should be for nitrogen 0·0015, for oxygen 0·000076, as a *maximum*, equal to a tension for O of one ten-millionth, and for N of one 500,000th, of an atmosphere. Thus by means of liquid H, as good an exhaustion should be attained as by boiling out a space with mercury, and with much greater rapidity. The same conclusion is derived from the molecular latent heats of H and O. Figures are given of apparatus by which this result was successfully achieved, with the precautions for excluding or recognising impurities. The incondensible residues from air were examined for the author by Liveing and Crookes, and the lines of neon, helium, and in one case hydrogen, were identified. By means of liquid H, the yellow line of neon 5849 can be detected in 25 c.c. of ordinary air. The presence of free H in the air is a question for further inquiry.

S. R.

593. *Retention of Gases by Metallic Oxides.* **T. W. Richards.** (Amer. Acad. Proc. 33. pp. 399–426, 1898.)—A continuation of the author's research in the same journal (26, p. 281) on the influence of time and temperature on these phenomena in the case of Zn and Cu oxides. For the thermometric measurements the method of standard melting-points is adopted, and a table is given of these values as found by Carnelley, Le Chatelier, Meyer, and Ramsay, with the results selected as probable. The oxides had been prepared from the nitrates, and it has long been known that the gases result from the decomposition of traces of undecomposed salt remaining in the substance. The heating was carried out in platinum crucibles in a simple furnace described, and the oxides afterwards dissolved in acid in a bulb apparatus figured in the previous paper, the gases being collected and measured over boiled water. In the case of the cupric oxide it was confirmed that it contained 4 to 5 vols. of occluded gas, which was nearly all retained up to 860°, at which point more than $\frac{9}{10}$ was rapidly set free. Above this the CuO commences to decompose, and at about 1,000° fuses into a mixture of CuO and Cu_2O. Prolonged ignition below 450° does not affect the amount of gas retained. At the higher temperatures the oxygen escapes more rapidly than the nitrogen. ZnO behaves similarly, but the O_2 is less readily evolved. Determinations of the conductivity proved that CuO is slightly dissociated at a red heat, ZnO less, and MgO

scarcely at all; hence it is necessary when absorbing O_2 by hot copper to keep the temperature moderate. Incidentally the author discusses the frequent presence of H_2 in CO. S. R.

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594. *Isothermal Pressure-surface for a Mixture of Two Single and One Resulting Double Salt.* **F. G. Donnan.** (Journ. Phys. Chem. 2. pp. 417–420, 1898.)—This surface for temperatures in the region of complete stability of the double salt appears to be saddle-shaped, and its discussion shows that the phenomena of isothermal evaporation can be very fairly well considered by means of it alone. R. E. B.

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595. *Conductivity of Solutions of Double Salts.* **J. G. MacGregor** and **E. H. Archibald.** (Phil. Mag. 46. pp. 509–519, 1898.)—The authors calculate the conductivities at various dilutions of a mixture of potassium sulphate and copper sulphate in such proportions as to be equivalent to the double sulphate. They find that the calculated values agree with those obtained by experiment for a solution of the double salt up to a concentration of about 0·1 gramme equivalent per litre, but at greater concentrations the double salt has an appreciably smaller conductivity than the equivalent mixture. This is not the case in a mixture which does not give rise to a double salt. The smaller conductivity is therefore evidence of double-salt molecules in solution.

W. R. C.

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596. *Electrolytic Estimation of Lead.* **A. Hollard.** (Bull. Soc. Chim. [iii.] 19. p. 911, and Écl. Électr. 17. pp. 566–569, 1898.)—As the result of careful study of the precautions which it is necessary to observe in the accurate estimation of lead, it is found that closely coherent deposits, having exactly the composition PbO_2, are obtained by electrolysis for 24 hours with a current of 0·45 ampere between platinum electrodes. The solution, measuring about 350 cc., should contain 80 cc. of free nitric acid and not more than 0.2 gram of lead; it is important that the deposit should be dried at 200°. The process is applicable, with slight modifications, to the estimation of lead in its alloys with zinc, tin, and copper, but not to those containing antimony.

N. L.

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597. *Electricity as Applied to Metallurgy.* **R. Threlfall.** (Australian Mining Standard, 12/8/97. Elect. Rev. 44. p. 397, 1898.)—The latter journal publishes an abstract of a long article by Threlfall upon the theory and practical applications of electro-metallurgy. The practical portion of the article is stated to be somewhat out

of date, but the theoretical part is interesting by reason of the presentation of Threlfall's own views upon electrolytic dissociation. He does not consider that it is yet proved that "ionisation" of a dissolved salt carries with it the electrostatic charging of the "ions"; and he inclines to the belief that such charging of the "ions" only occurs when they are engaged as carriers of a current through the solution. His arguments in support of this modification of the generally accepted theory, will be found stated at length in the original.

The practical portion of the article deals with the following industrial applications: Electro-plating, copper extraction, zinc extraction, copper refining, silver refining, soda and bleach manufacture, and the production of hypochlorites, aluminium, and calcium carbide. J. B. C. K.

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598. *The Electro-Chemical and Electro-Metallurgical Industries in* 1898. **J. B. C. Kershaw.** (Elect. Rev. 44. pp. 42–43; pp. 107–108, 1899.)—The writer refers to the chief events of 1898 in connection with these industries generally, and then deals with the progress of the more important branches of industry.

Alkalies and Bleach.—The Greenwood process, and its trial at Winsford, the Rhodin Cell litigation, the growth of the Castner Kellner Works at Weston Point, and the proposed new works for operation of the Hargreaves-Bird process in Cheshire, are referred to. The writer states that the German companies are showing the greatest activity, and it is as a result of their rapid development that Germany is now exporting large quantities of bleach.

The number of electrolytic alkali works in operation at the end of 1898 is estimated to have been 14; while 11 additional works are in course of construction, and will commence to manufacture during 1899.

Aluminium.—The progress in this industry is slow but steady. A new process, the Péniakoff process, is on trial at Selzaete in Belgium. During 1898 aluminium has been used for reducing refractory oxides, and as an electrical conductor for long distance transmission schemes. Each of these new uses may become of industrial importance. The rise in the price of copper is increasing the prospects of success, as regards the latter use of aluminium. Eight works, all operated by water-power, with an aggregate output of 25,000 lbs. of aluminium per day, were in operation at the end of 1898.

Calcium Carbide.—This has been the most active of these new industries during 1898, but the writer considers this activity is premature, and that financial losses will ensue. The number of carbide factories in operation at the end of 1898 is estimated at 32; and 19 additional factories are to be put in operation during the present year. During 1898 the Bullier carbide patents have been declared void in Germany; while litigation over the

Wilson patents has entered upon its preliminary stage in this country.

Copper.—The leading feature of 1898 in this industry is stated to have been the depletion of stocks, and consequent rise of price. The writer estimates that the production of electrolytic copper in Europe in 1898 amounted to between 25,000 and 30,000 tons; and that the total output of the European and American refineries was 170,000 tons. English refiners have suffered from scarcity of supplies; but recent changes in smelting charges will, it is hoped, remove this difficulty. The number of electrolytic refineries in operation in 1898 is stated to have been 36. Three new refineries were in course of construction in America, and will come into operation during 1899.

Chlorates.—This electro-chemical industry is not yet represented by a manufactory in this country; but it is stated that during 1899 one will commence operations in the Midlands, using coal as a source of power. The cause of the delay has been the absence of large water-powers, and the fear that steam-power would prove too costly. The writer states that the number of works engaged in this manufacture abroad is 7; the aggregate H.P. in use is 30,000; and the annual output of chlorates is about 6,500 tons.

Hypochlorites.—The use of hypochlorite solutions for bleaching purposes is extending, and many works on the Continent now possess their own electrolytic bleaching plants. The Kellner, Corbin, and Vogelsang forms of apparatus are stated to be in use. A trial of one of these electrolysers is likely to occur in this country during the present year. The experiments with the Hermite process of sewage treatment at Bombay have failed, owing to the excessive cost. The writer states his opinion that the success of the bacterial method of sewage treatment will render further competition of electro-chemical methods hopeless.

Ozone.—The year 1898 has not witnessed much progress in the industrial application of ozone. The experimental trials of the Tindall-Schnelle method of water purification still continue at Oudshoorn, and Blankenberg; but cost details are lacking. The Rosenblum-Yarnold process of thickening and bleaching oils, has yielded successful results; but there is some delay in floating the company, which is to carry on this process on a large industrial scale.

Zinc.—The writer states that the chief event of 1898 in this industry has been the definite abandonment of the Ashcroft process, after lengthy trials at Newcastle, N. S. Wales. The Hoepfner and the Dieffenbach processes are, therefore, now the only two electrolytic zinc processes in operation upon a commercial basis. The joint production of these processes in 1897 is estimated to have been 2,200 tons. The Cowper-Coles and the Nahnsen processes are being worked experimentally, in Cornwall and in Silesia respectively.

The writer believes with others that the refractory sulphide ore problem will be solved by a fusion process, and on this account calls special attention to the Swinburne and the Fry processes. The former is now on experimental trial in London; the latter is to be worked in 1899 upon an enormous industrial scale at Manchester. The Swinburne process depends upon the electrolysis of a fused bath of sulphides and chlorides; the Fry process is wholly metallurgical in character.

As regards electro-galvanising, the writer states there is nothing new to report. AUTHOR.

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599. *Cleaning Metallic Surfaces by Electrolysis.* **C. F. Burgess.** (Elect. World, 32. pp. 445-447, 1898.)—In this article the author discusses the various methods of cleaning metallic surfaces by electrolysis, and states that the most advantageous arrangement, except when it is required to remove thin coatings of metal, is to make the metallic object to be cleaned the kathode in a strong NaCl or NaHO solution, using a carbon anode. By this means, both chemical compounds of the metal and grease, oil, and other foreign substances are removed without affecting the metallic object itself, since any oxide, sulphide, chloride, or similar compound will be reduced by the Na or nascent H, whilst the oil or grease will be saponified by the NaHO. With a greasy iron surface and a nearly saturated solution of NaCl, and 20 A. per square foot, time required = 15 min.; 40 A. per square foot, time = 3·5 min; 140 A. per square foot, time = 0·75 min. With a KHO solution, a current density of 80 A. per square foot cleaned the iron almost instantly. With a current density of 40 A. per square foot, at 5 volts, the cost of power for cleaning is about 0·06 cent per square foot, assuming power at 4 cents per H.P. hour. Paint, lacquer, enamel, &c., can be similarly removed. C. K. F.

GENERAL ELECTRICAL ENGINEERING.

600. *Accumulators for Auto-cars.* **J. Reyval.** (Écl. Électr. 17. pp. 313–317, 407–410, and 545–547, 1898.)—The author describes, with diagrams, the construction of the Fulmen accumulator (see 1898, Abstract No. 965), the Faure-Sellon-Volckmar accumulator, and the accumulator constructed by the *Société anonyme pour le travail électrique des métaux.* Tables are given of the specific constants of these different types. N. L.

601. *Zinc Accumulators.* **G. Pellissier.** (Ecl. Électr. 17. pp. 341–345, 1898.)—Twelve watt-hours per kg., including acid and ebonite case, is the highest figure given by any European or American maker of accumulators. Riker is therefore trying cells with lead positives and zinc-coated copper negatives. They give a mean E.M.F. of 2·3 and a maximum of 2·5 volts, and a battery weighing 345 kg. (inclusive) has a specific energy of 36·4 watt-hours per kg. for ten hours, or 29·15 watt-hours per kg. for four hours. E. H. C.-H.

602. *Fulmen Accumulators and Motor Cabs in Paris.* **E. Hospitalier.** (Soc. Int. Elect. Bull. 15. pp. 275–326, 1898.)—The Fulmen cell used by all the cabs were found to be as follows:—

6 positive plates having 135 grms. of lead and 340 grms. of paste each.
7 negative plates having 135 grms. of lead and 255 grms. of paste each.
21 square decimetres of positive plate.
The containing vessel and separators weigh 600 grms.
The total weight of the accumulator and liquids is 7½ kilogrms.
Normal discharge 21 amps. for 5 hrs.; mean voltage 1·9.

Details and diagrams of all the cabs are given as well as daily expense of current. (See also 1898, Abstract No. 965.) M. O'G.

603. *Long-Schattner Electrolytic Prepayment Meter.* (Elect. Rev. 43. pp. 771–773, 1898.)—This is an electrolytic meter in which a copper anode plate is suspended from one arm of a balance-beam, this arm also bearing boxes for receiving coins or standard weights to replace coins, and a bridge-piece forming part of a mercury-cup switch; the other arm of the balance-beam bears a counterweight. The mercury in the cup at which the circuit is broken is covered with a layer of creosote oil, producing a perfectly

sparkless "break" and "make" even at full load. The copper sulphate solution is of 1·115 sp. gr. and made up with 1 per cent. of H_2SO_4 and 99 per cent. of H_2O, evaporation being prevented by a thin layer of ordinary machine oil. The depositing cell is arranged as a shunt to a resistance in the main circuit, and the mercury cups of the switch are connected through a high resistance so that, when an amount of copper equivalent to the weight of the coin inserted has been removed by the current from the anode, the bridge-piece will break the connection at one of the cups; the lamps, however, will not go out, but will burn dim, being supplied through the above-mentioned resistance; the current so used is paid for out of the coin next introduced. One copper plate and box will last for 700 units and then has to be replaced by a fresh plate and box at a cost of 5s. The meter is in use at Norwich. C. K. F.

604. *Compensating Frictional Resistance in Siemens Electric Meter.* (Zeitschr. Elektrotechn. Wien. 16. pp. 431–433, 1898; German Patent, No. 98211.)—This meter has an annular core with four inwardly directed polar extensions, a drum-shaped copper armature and an internal core, all these parts being somewhat similar to those shown in the diagram on p. 64 of this volume of SCIENCE ABSTRACTS. In the present case, however, the pole-pieces have no lateral extensions and the series coils are wound on one pair of the diametrically opposite pole-pieces, whilst shunt coils are wound on the remaining two diametrically opposite pole-pieces, 90° difference of phase being produced in any suitable manner between the shunt current and the main current. In order to compensate for the frictional resistance to rotation of the armature, a suitable number of turns are wound around one of the quadrantal sections of the core, this coil being arranged as a shunt to a suitable resistance in the main circuit. This produces a weak additional or superposed turning-moment on the armature of the required amount. C. K. F.

605. *American Lightning Arresters.* **H. E. Raymond.** (Amer. Electn. 10. pp. 497–501, 1898.)—This is an illustrated article containing a descriptive, but not comparative, account of various types of American lightning arresters for both direct and alternating current circuits. In describing the Wurts arrester the author quotes some of the results obtained by Wurts on non-arcing metals. The principal non-arcing metals are zinc, cadmium, mercury, antimony, bismuth, and their alloys or amalgams. W. G. R.

606. *Electric Alarms.* **J. Ebel.** (Elect. Rev. 43. pp. 649–651, 1898.)—This article describes two inexpensive forms of ordinary electric bells in which a straight electromagnet core has a laterally extending pole-piece at each end, one of which serves as a base and the other is provided with a bracket for the spring bearing the armature, contact-piece, and hammer. Another arrangement is dust-proof and water-tight, this being obtained by arranging the parts within a box having a diaphragm against which the hammer strikes. A closed-circuit differentially-wound burglar-alarm is also shown and described, together with a special form of alarm suitable for large sizes, in which a solenoid is employed having a reciprocating core controlled by a helical spring and moving on balls arranged in longitudinal grooves therein; in this case, the circuit is completed and broken at the calling station. C. K. F.

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607. *Electrically Driven Turntable.* (Elect. World, 32. p. 401, 1898.)—In this turntable, the table platform is supported on two longitudinal girders resting on an equalising drum which turns on a set of rollers. The 15-H.P. motor is series-wound and arranged with its armature-shaft in a vertical position, this shaft being connected, through double-reduction gearing, with a shaft bearing at its lower end a pinion engaging with a circular stationary rack. The table can be turned through an arc of 180° in half a minute, the current (30 A.) being cut off when the table has moved through about 30° or 35°. The cost per month, including attendance (2 men), current, and 10 per cent depreciation on electrical equipment only, is 310 dollars (?). C. K. F.

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608. *Effect of Fire-damp on Incandescent Lamp Filaments.* **H. Couriot** and **J. Meunier.** (Comptes Rendus, 127. pp. 559–561, 1898.)—The authors introduced an explosive mixture of fire-damp and air (9·5 per cent of methane) into the bulbs of electric incandescent lamps either before or during incandescence of the filament, so as to reproduce the conditions which sometimes obtain when the lamps are used in coal-mines. Lamps of from 15 to 110 volts and differents currents (up to 2·15 A.) were experimented with, and it was found that, *with none of the lamps in which the filaments were not previously broken, was there produced an explosion of the most explosive gaseous mixture.* In general the incandescence rapidly diminished save at one point (the upper part) of the filament, which retained its brightness and at which the rupture took place with a small spark after about a minute, the broken ends of the filament being reduced to fine points. There was no different effect produced when the filaments were overrun. The authors remark that the results obtained are in accordance with the fact discovered by them

(Comptes Rendus, 126. p. 752), that incandescent metal wires are incapable of detonating the most explosive mixture. In the present experiments the fire-damp burned quietly without flame and, after the cooling of the lamp, drops of condensed water from the combustion were found on the wall of the bulb. The remaining gas turned lime-water milky and could not be ignited by a match, thus accounting for the harmlessness of the spark on rupture. The authors, however, succeeded in producing an explosion on jolting a lamp, the filament of which had previously been broken; even in this case, the first sparks did not produce any effect. C. K. F.

609. *Electrically Driven Shipyard Tools.* **F. von Kodolitsch.** (Cassier, 14. pp. 488–498, 1898.)—This article gives short descriptions and photographs of electrically driven boring machines, a bolt-hole reaming-machine, key-cutting machine, punch, tube-expander, crane, winch, portable fan, pump, saw, cylinder-boring machine, lift, and capstan. C. K. F.

610. *Electric Dumb Waiters in the Chicago Public Library.* (Elect. Engin. N.Y. 26. pp. 329–330, 1898.)—This is a detailed account of the motor-driven dumb waiters at the Chicago Public Library. These waiters are capable of handling 10,000 to 12,000 books per day. W. G. R.

611. *Electric Cranes at Southampton Harbour.* (Electrician, 42. pp. 123–125, 1898.)—This article describes three 3-ton cranes and a combined 3-ton and 12-ton crane constructed by Stothert and Pitt, of Bath. Photographs and several scale drawings of various parts are given in the original paper. C. K. F.

612. *Electrical Refrigeration.* **T. F. Fay.** (Elect. Engin. N.Y. 26. pp. 331–332, 353–354, 378–380, 1898.)—These articles discuss the arrangement of electric motors for driving refrigerating machinery and give particulars and drawings of several installations of this kind; the relative advantages of ammonia, sulphur dioxide, Pictet fluid (SO_2+a small percentage of CO_2), carbon dioxide, methylic ether and chymogene are also set forth. The average cost of 1 ton of ice using electric motors, assuming power at 5 cents per kilowatt, and that 1 kw. hour for 24 hours will be required, will be

24 kw. hours at 0·05	$1·20
1440 gallons of water	·15
Oil, inspection, &c.	·15
	$1·50

C. K. F.

613. *Erecting a High Pressure Transmission Line.* **S. H. Dailey.** (Amer. Electn. 10. pp. 454–455, 1898.)—This is a third article (see 1898, Abstracts 1095 and 174) on the practical erection of a high pressure transmission line and contains instructions regarding the erection of the poles, with a list of the necessary raising tools. W. G. R.

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614. *Electrolysis of Cast-Iron Pipes.* **H. P. Brown.** (Elect. Engin. N.Y. 26. pp. 441–442, 1898.)—In this paper, read before the American Society of Municipal Improvements, Washington, the author states that cast-iron pipes are usually but little affected by electrolysis since the coating of adherent moulding sand and tar paint protects them. In the ordinary soil, an iron pipe submitted to electrolytic corrosion is covered with a layer of iron oxide, which is a poor conductor of electricity, so that, with a given pressure, the deeper the layer of rust the slower is the rate of corrosion. In the case of cast-iron pipes at Dayton, Ohio, the surrounding soil seems to give a different reaction when a current passes through it. The tar appears to give no protection whatever, and the surface of the pipe is changed into a soft black material resembling graphite, and easily cut with a knife. The chemical analysis of the pipes shows that the percentage of iron is greatly diminished while the percentage of carbon is more than doubled.

The author recommends the use of wooden pipes in districts covered by electric mains. W. G. R.

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615. *By-Products of Power Plants.* **M. M. Fenner.** (Elect. Engin. N.Y. 26. pp. 334–337, 1898.)—The author describes a method of utilising exhaust steam for the heating of buildings, which has been successfully adopted by the Dunkirk and Fredonia Railroad Company. The supply mains consist of an iron pipe to convey the steam, wrapped in asbestos. This is placed on rests 1 inch high within bored logs, the bore being 2 inches greater than the diameter of the pipe so as to give 1 inch of dead air round the pipe; the log has a shell 4 inches thick, waterproofed and lined with tin, the whole being wrapped with three-ply tarred roofing felt and laid on boards at the bottom of a 5-foot trench; expansion joints in brick chambers are provided where necessary. About one mile of these mains has been laid by the company. The most economical steam pressure for heating purposes has been found to be from 4 to 6 lbs., the circulation being maintained by draft from condensation. The condensed water is collected from the pipes into cooling coils, and after losing nearly all of its heat passed into the sewers.

The author estimates that the exhaust steam from a 100-H.P. engine will efficiently heat 1,000,000 cubic feet of space in average buildings in the severest weather. During hours of light load on the engines the exhaust steam can be supplemented by live steam from the boilers without pecuniary loss.

The steam is supplied by meter and has formed a valuable addition to the company's revenue. M. G. W.

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616. *Electric Canal Haulage.* **A. H. Allen.** (Electrician, 41. pp. 851–853, 1898.)—The decay of the vast system of canal communication in England is due chiefly to the slow speed of transmission as compared with that of railways and coasting steamers, and the heavy charges for tolls and for towing. The method of hauling in general use remains the same as it was a century ago—by horses. Steam tug-boats have been tried, but have not proved satisfactory. The subject of this paper is an adaptation of electrical traction to canal haulage, with a view to accelerating the speed and at the same time reducing the cost—the two most important considerations in connection with goods traffic. The system described by the author is the outcome of long study on the part of Messrs. Thwaite and Cawley, their aim being to provide an economical and efficient method of haulage, which can be applied to any canal without in the least interfering with the use of horses—thus enabling the latter to be dispensed with by degrees if desired. The author describes several methods of electric canal haulage in use at the present time.

In the system under consideration the motors are made entirely independent of the barges, the latter being hauled by means of ropes, exactly as with horses; in this way the waste of energy incurred with a screw propeller is almost entirely obviated. An ærial railway is provided consisting of two steel rails of channel or **Z** section, braced together at one side so as to form a rigid girder, and supported at a height of 9 or 10 feet above the towing-path by means of cast-iron brackets or wooden posts at intervals of about 30 feet. Each of these rails constitutes a running track for a number of electric locomotives, each consisting simply of an electromotor mounted on a four-wheeled carriage; two of the wheels run upon the upper surface of the rail, supporting the weight of the locomotive, and two run beneath the rail, bearing against the lower surface in such a way as to ensure the stability of the locomotive. The motor shaft carries at each end a worm gearing with a worm wheel on each of the four axles, so that all the wheels are drivers; the gearing runs in an oil bath, and can be so designed as to give an efficiency of 90 per cent. Automatic lubrication is provided for all the working parts, so that frequent inspection is not necessary.

The motor itself is of the ordinary direct current series-wound traction type. The tractive force required to tow a barge carrying 100 tons on a canal of ordinary cross-section at the rate of 2½ miles per hour, is from 250 lbs. to 300 lbs. The maximum brake horse-power at full speed is therefore 2-B.H.P. To the lower side of each rail is bolted a continuous creosoted wood batten, which supports the electrical conductor, the latter being thus protected from the weather and from mechanical injury.

It is arranged that the two rails form an "up" line and a "down" line, so that the locomotives run on the upper rail in one direction, and on the lower rail in the opposite direction.

The locomotive is controlled entirely from the barge, no driver being required. When starting up to a speed of 4 miles an hour, the current at 500 volts would not exceed 14 to 15 amperes. So that elaborate switching apparatus is not necessary.

The considerations as to position and arrangement of generating stations are fully gone into.

In order to illustrate the economic possibilities of the system, estimates have been prepared of which the following are the results in brief:—

	Cost per ton mile.	Time occupied in transit.
Haulage with horses at 2½ miles per hour.	0·077d.	15 hours.
Electric Haulage at 2½ miles per hour...	0·032d.	12 hours.
Electric Haulage at 4 miles per hour ...	0·041d.	7½ hours.

The electrical system of haulage possesses the following advantages among others: — The boats require no attention whatever. The delays in passing incurred with horse haulage are obviated. Bridges and tunnels cause neither difficulty nor delay. No time is lost in waiting for a train of barges to be loaded, as is the case with steam. Power can be supplied to private consumers, &c., at a low rate. The cost of haulage is reduced by 50 or 60 per cent; and the time occupied in transit by 20 to 50 per cent. as compared with horse haulage. In case of frost, the standing expenses are much less than with horses.

L. J. S.

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617. *Electric Traction on Canals.* **Van der Wallen.** (Bull. Ass. Ing. El. Liège, 9. pp. 309–406, 1898.)—The author reviews the whole subject of mechanical traction on canals, and after dealing with funicular haulage in detail, discusses (1) haulage by mechanical means from the towing-path; (2) propulsion by portable apparatus placed on board the barges. On the Burgundy Canal the Galliot system is in use; an electric tricycle is propelled along the towing-path by a 6-kw. motor, receiving energy from a suspended trolley wire, and hauls barges by means of a tow-rope. The tricycle weighs two tons, and tows a train of barges loaded

with 700 tons at about 1¼ miles per hour. The power required is as follows:—

Load.	Speed.	Power.
387 tons	1·25 miles per hour	3·45 kilowatts
186 tons	1·37 do. do.	1·8 do.
Tricycle alone...	3·75 do. do.	0·9 do.

Lamb proposes to use a telpher line, consisting of two overhead insulated cables, upon which runs a suspended motor hauling the boats with a tow-rope. Various types of rudder-motor propellers are described, and the use of accumulators is discussed. On another part of the Burgundy Canal the Bouguié system of chain haulage is employed; in this case energy is supplied by means of two trolleys and trolley wires to a motor carried on the barge, which drives the chain-hauling gear. The average cost is 0·67d. per ton, as compared with 0·98d. for steam haulage, for the journey of 3·75 miles (of which two miles are in a tunnel).

The author gives details of the process of estimating the power required for electric traction, and discusses the relative advantages of direct and polyphase currents for power transmission, preferring the latter system. The paper concludes with a summary in which the shape of the barges and of the section of the canal are discussed, and the various systems are compared with one another and with animal haulage with regard to fixed and running costs and volume of traffic. A. H. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

618. *Dynamo Design.* **C. P. Poole.** (Elect. World, 32. pp. 555–557, 1898.)—Five years ago the author published a method, then in use by himself, the object of which was economy in time in making preliminary calculations for the dimensions of dynamos and motors. Since then the method has been modified to make it applicable to standard practice in designing, irrespective of personal preferences as to minor details.

The "method" consists in basing the calculations for output upon the peripheral velocity, air-gap density, and number of conductors, and in adopting at the outset fixed values for the peripheral velocity, air-gap density and proportion of armature covered by the pole-pieces for each line of machines of a given type. A number of formulæ are given and analysed, and examples worked out.

The author also gives a formula which should prove convenient for arriving at the necessary coil space on the field-magnet cores:—

$$\sqrt{\frac{\text{V At}}{\theta\delta\text{G}10^4}} \times d_1 = \text{L}$$

Where L represents the length along the core in inches; d_1, the diameter of the wire over the insulation in mils.; δ, the depth of the winding in inches; G, the perimeter of the coil in inches; and θ, the rise in temperature, Fahr.; At, the number of ampere turns; and V, the pressure at the terminals of the field coil. The result cannot be absolutely accurate, because the "imbedding" of the wires of each layer between those of the layer below, which varies with each size of wire, renders it difficult to obtain on paper the exact value of δ. If the coefficient of shrinkage due to "imbedding" be ascertained experimentally for each size of wire, δ can be given a precise value. L. J. S.

619. *Tests of Rushmore Multi-Circuit Dynamo.* **E. J. Murphy, jr.,** and **P. E. van Saun.** (Amer. Electn. 10. pp. 494–497, 1898.)—The authors give the details of a test of a Rushmore multi-circuit dynamo in which there are two circuits at different pressures. The adjoining diagram of the machine shows the connections with the external circuits.

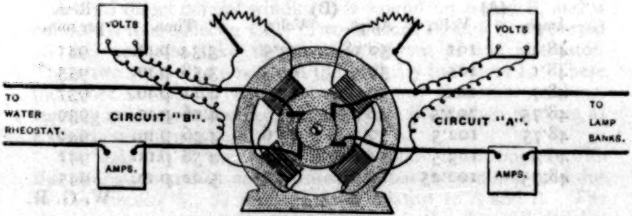
The test was made with a dynamo of 20 kilowatts capacity, and comprised the following :—

1. The effect produced upon the pressure of the circuit A (see fig.) by altering the pressure in circuit B without altering the external resistance in that circuit.

2. The effect produced upon the pressure of circuit A by keeping the current in circuit B constant, and reducing the pressure in that circuit from 110 to 0.

3. A determination of the efficiency of the dynamo when connected as a single-circuit multipolar machine at various loads up to the capacity of the machine.

4. A determination of the efficiency of the dynamo, when connected as a multi-circuit machine, circuit A only being closed and the load raised to 90 amperes.



FRONT VIEW

5. The efficiency of the dynamo when connected for multi-circuit work under the conditions previously given for tests 1 and 2, and also when the current in B is kept constantly at 50 amperes.

6. The amount of power consumed in friction by the bearings and brushes.

7. The power absorbed by the dynamo in eddy currents, friction, and hysteresis losses under various conditions.

8. External characteristics under various conditions of operation.

The variation in the pressure of circuit A when the E.M.F. and current in circuit B are varied is shown in the following table in which the results are the average of three readings taken at two-minute intervals. In Table A the performance of the machine is shown when the E.M.F. and current in B are varied, the resistance being kept constant. In the case of Table B the current was kept nearly constant by varying the external resistance; the pressure was lowered in steps in circuit B. The results show that circuit A is practically independent of circuit B, though it might be supposed that the variation of the pressure in one might affect the output of the other.

TABLE A.

(A)		(B)			Revs.
Amps.	Volts.	Amps.	Volts.	Time.	per min.
48·25	96·6	51·2	111·8	2.48 p.m.	931
50	100·6	42	91·6	2.54 p.m.	945
50·7	101·5	32·7	71·6	3.00 p.m.	943
50·5	101·2	24·8	54·4	3.06 p.m.	938
50·25	100·6	13·4	29·3	3.12 p.m.	941
50	100	5	11	3.18 p.m.	943
49·75	99·6	1·5	4	3.24 p.m.	942
50·5	101	0	3	3.30 p.m.	949

TABLE B.

(A)		(B)			Revs.
Amps.	Volts.	Amps.	Volts.	Time.	per min.
48·1	101	50·58	113·5	3.34 p.m.	941
48·1	101	50·5	90·5	3.58 p.m.	933
48·7	102	50	70·3	4.11 p.m.	937
48·75	102·5	48·75	47	4·26 p.m.	939
48·75	102·5	50·3	29·6	4.36 p.m.	940
49·3	103·5	51·16	10	4·58 p.m.	941
48·75	102·25	0	3	5.02 p.m.	945

W. G. R.

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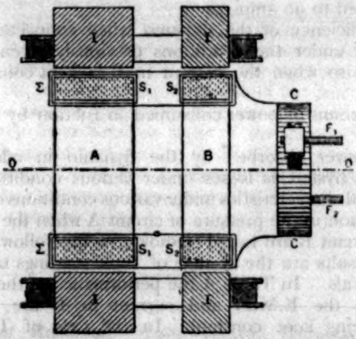
620. *Compounding Alternators for Constant Pressure.* **M. Leblanc.** (Comptes Rendus, 127. pp. 716–719, 1898.)—This article describes an arrangement by means of which the exciting current of an alternator is made proportional to the output.



Suppose the alternator to be for three-phase currents, then in the figure two rings A and B are placed on an axis OO. The ring A carries a first winding S_1 of the rotary machine which consists of a number of circuits at a fixed angular distance apart equal to those of the armature of the alternator. They are connected in series with the corresponding circuits of the alternator by means of rings and brushes. The ring B carries a second winding S_2 similar to that in A, but connected in parallel with the armature circuits of the alternator by means of rings and brushes. The two rings A and B are keyed on to the shaft OO in such a way that the plane passing through the axis and the middle of the ring A, makes with the plane through the axis and the middle of the ring B an angle ω, given by $\tan \omega = \frac{2\pi n L}{R}$ where n is the frequency, and L and R the self-induction and resistance respectively of each armature circuit.

A third direct current winding Σ is wound on A and B, and is connected to a collector CC. Two brushes F_1 and F_2 supported on this collector take the exciting current of the alternator. These two rings rotate between the ordinary inductors I. These inductors should be fixed in such a way that the machine, running at its normal speed, cannot excite itself when working as a direct-current machine.

The axis OO of the exciter should rotate synchronously with the alternator and in such a direction that the rotating field due to the circuits S_1, S_2 remains fixed relative to A and B. The continuous current-winding moving through this flux will develop a constant pressure between the brushes F_1 and F_2.

The exciter, thus wound, works as an ordinary converter without having any mechanical connection with the accompanying alternator. It takes from the circuits S_1 and S_2 the energy necessary to keep up its motion, and to produce the continuous current which is collected at the brushes. W. G. R.

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621. *Commutator Design.* **F. J. A. Matthews.** (Elect. Rev. 43. pp. 584–586, 1898.)—In discussing the cost of production of modern direct current dynamos, the author considers that owing to increasing wage rates and shop expenses the cost of production is more likely to have an upward rather than a downward tendency in the future. There is, however, ample room for improvement in many of the machines now on the market. It is questionable whether in cotton mills, for instance, where the hours of lighting do not exceed 500 per annum, it is not more economical for the mill owner to purchase for less money a dynamo having a lower percentage of efficiency than pay a high price for a machine with an efficiency of 94 per cent., as the saving in coal is not commensurate during such short runs with the percentage set aside for depreciation and interest. But what is of the very greatest importance is that the machine when set

to work should run with the minimum of attention and absolutely no sparking. The causes of sparking are classified as follows:—

1. Faults inherent in the dynamo design.
2. Faults due to the bad setting of the brushes.
3. Causes entirely outside the machine.
4. Faulty construction of the commutator.
5. Bad connections.
6. Commutator too small.

The article discusses the three latter causes and briefly dismisses the first three. The author points out that a commutator is a most unmechanical construction, judged from an engineering standpoint; yet, with careful designing and supervision during construction and in the hands of an attentive dynamo tender, there is no reason why this, which has always been the weak part of direct current machines, should not retrieve its character.

L. J. S.

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622. *Thickness of Transformer Plates.* **F. Bedell, R. M. Klein, and T. P. Thompson.** (Phys. Rev. 7. pp. 242–245, 1898.)—There is evidently a best thickness for transformer stampings since as the thickness diminishes the proportion of insulation increases as also does the induction density and consequently the hysteresis loss per c.c. of iron in the core.

The hysteresis and eddy current losses in watts are represented respectively by—

$$W_h = V\eta\, n\, B^{1\cdot6}\, 10^{-7}$$

and

$$W_e = V\gamma\, (tn\, B)^2\, 10^{-21}$$

where V is the volume of iron in c.c., n the frequency, B the maximum induction, η a hysteresis coefficient dependent upon the quality of the iron, t the thickness of the plate in mils. including oxide or insulation, and γ is the conductivity of iron.

From these formulæ the authors draw curves for different thicknesses of plates and different frequencies and compute that the range of best thickness of transformer plates, for usual frequencies, is from 10 to 15 mils.

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

623. *Pressure Regulation in Three-wire Systems.* **C. del Proposto.** (Écl. Électr. 17. pp. 221–229, 1898.)—Two conditions are to be fulfilled: the maintenance of constant pressure between the outers and the equal division of the pressure between the two branches. Where the variations of load are sudden and great, ordinary methods of regulation are too slow to cope with them. The author discusses the use of two dynamos in series, compound wound to give constant pressure at the feeding point when the load is balanced, and provided with supplementary field coils in series with each other and with the middle wire, which compensate for the drop in the middle wire when balance is disturbed. The theory of the method and the mode of calculating the windings are given, and an alternative arrangement is described. The pair of machines must be designed to suit a particular three-wire feeder, and special provision must be made if the machines are to be interchangeable with others, and to run in parallel with others.

Similar methods are applied to the case of two-wire feeders with balancing machines in substations. It is shown that the ordinary system of two shunt-wound dynamos coupled together can never give true equality of pressures when the load is not balanced, since the resistance of the armatures cannot be zero. The defect is remedied by exciting the shunt winding of each machine from the terminals of the other, when exact balance will be maintained provided the magnetisation characteristics of the machines fulfil a simple condition. Two devices of Siemens and Halske are discussed, which involve the use of supplementary field coils in series with the middle wire; these are said to be inferior to the first method in efficiency. In all three methods, two separate machines coupled together are necessary, instead of a single field and double wound armature. The variations of speed of the armatures are discussed, with the aid of graphic methods; these variations are small, but very detrimental to regulation when the load varies widely and suddenly. The application of the system to five-wire networks is also briefly discussed. A. H. A.

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624. *Transmission Plant of the Fries Power Company.* (Amer. Electn. 10. pp. 447–450, 1898.)—This installation derives its power from the Yadkin river, a dam having been built across the stream giving an available head of 10 feet. The plant at present installed consists of 8 vertical turbines of 165 H.P. each, geared to a horizontal shaft, and a 750 kw. generator of the 3-phase inductor type wound to give 12,000 volts at 166 revolutions per minute, thus obviating the use of step-up transformers.

The main transmission line is carried on poles, the distance being $13\frac{1}{2}$ miles. Induction motors are used when the units do not exceed 50 H.P. and synchronous motors for larger units. The power at the generating station will shortly be doubled.

M. G. W.

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625. *Electric Traction.* **C. A. Carus-Wilson.** (Soc. Arts Journ. 46. pp. 833–843, 845–854, 857–869, 873–883, 1898.)—The first of these Cantor Lectures deals with motors at rest. The "induction factor" M of a motor is expressed as follows: $M = pAN10^{-8}$ where A represents the number of conductors on the surface of the armature, N is the number of useful lines of force which enter the armature from any one pole, and p is the ratio of the number of surface conductors in series between the main terminals of the machine to the number of surface conductors lying between two adjacent neutral points: in a two-pole machine p will be unity, but in a four-pole machine it will be two or one according to the armature connections. If t represents the torque on the shaft in inch-pounds, and the armature carries a current of C amperes, then $t = 1{\cdot}41CM$. Plotting the induction factors as ordinates and the amperes as abscissæ, we obtain the "induction curve" representing the magnetic condition of the motor at rest. To obtain the characteristic from this induction curve, we have only to multiply the value of M by the number of revolutions per second. Torque is proportional to MC, and hence in a series motor it would vary as the square of the current if the iron had no reluctance. Herein lies the great advantage of series winding for railway motors. Taking the difference between the curve of total torque calculated from the induction curve and the curve of useful torque found by test, we obtain the torque lost in friction of gear and bearings, hysteresis, &c., giving us the mechanical efficiency, which for a G.E. 800 motor is found to be 84 per cent.

Lecture 2 deals with the motor in motion. If the current through the armature of a revolving shunt motor is momentarily broken, the deflection on a voltmeter across the brushes hardly changes, showing that the motor itself is inducing a tension of the same sign with respect to the voltmeter as that of the line. If n is the number of revolutions per second of the motor, the back E.M.F. or "induced tension" is nM. The induction curve can most readily be calculated from the formula $M = (E - CR)/n$, where E is the pressure on the line and C and R are the current and resistance in the armature. When the speed is uniform the current through the motor is determined solely by the retarding torque on the shaft. Obtaining n from the above equation for M, we find that the speed is made up of two parts, one depending upon E and the other upon C which in turn depends on the load. We can thus determine the behaviour of shunt and series motors with varying load.

Passing on to the consideration of the motor under acceleration (A ft. per sec. per sec.) we have $A = 32{\cdot}2\ T/W$, where T is the difference between the assisting and retarding force and W is the weight of the revolving parts. It is therefore not a fact that a heavy train takes more current to start than a light one: we can make it take whatever current we like, but the rate at which it starts up depends on the amount of current. If we have the profile of a line, the resistances to motion and the induction curve of the motors, we can predetermine with remarkable certainty the shape of the acceleration curve, which is all important on such lines as the Central London where the motors hardly ever run for any time at full speed.

The third Lecture discusses the various methods of motor control. If we vary the resistance by means of a rheostat in series with the armature of the motor we can keep the acceleration constant as long as we have any resistance in circuit to vary: after this the acceleration begins to diminish. Given the curve of acceleration from rest, we can find the distance in feet that will have been covered in a given time by drawing a vertical line through the point in the time base corresponding to the given time and finding the area included between the line, the curve, and the time base. Similarly by drawing a vertical line through a given point on the time base of the current curve, we get an area representing the watt-seconds of work done up to that time. Acceleration and current curves taken from several railways are given.

The fourth Lecture shows how to determine the best equipment that will start a train from rest and carry it through a given distance in a given time. If a train weighing W tons has to be moved through D feet in t seconds, the diameter of its wheels being d, the velocity ratio of the gear v, and the induced volts e, then $s = 0{\cdot}262\ de/Mv$. Also the acceleration (a) in ft. per sec. per sec. is $a = 0{\cdot}04\ Mv/d \times C/W$. For a given equipment and a given value of D there is a best diameter for the wheels. The use of series winding reduces the heat loss and in consequence enables the car to be carried through a given distance in a given time with considerably less energy than with motors of constant induction factor. E. H. C.-H.

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626. *Accumulator Traction.* **M. van Loenen-Martinet.** (Rly. World, 7. pp. 304–305, 1898.)—In a report presented to the Permanent International Tramways Union, the author reviews the present position of accumulator traction. At Hanover the plates are estimated to last 35,000 to 45,000 car kilometres, and at Dresden from 20,000 to 23,000 car kilometres, the latter being equivalent to from 2 to 2⅓ years. There are 105 accumulator cars in regular use at Hanover and 40 in reserve. A reserve of 10 per cent. is sufficient to allow for the overhauling of batteries. After a car has run 10,000 kilometres by the accumulators, the

latter are cleaned without removing from the car, and plates replaced where necessary. This operation takes two days. A staff of twenty-five men is required to clean and repair the batteries, and the cost per annum per car is about £34 12s. 0d. At Dresden the batteries are cleaned at the end of six months, and the maintenance is guaranteed at a certain figure. The repairs are said to cost from 3·6 to 4·8 centimes per car kilometre, but this is probably too low. W. R. C.

627. *Conduit* v. *Trolley System*. **J. Young.** (Rly. World, 7. pp. 415–418, 1898.)—This is a report to the Glasgow Tramways Committee as to whether the conduit system should be experimentally tested upon a portion of the Glasgow tramways. The author refers to the figures recently published as to the comparative costs of cable, electric, and horse traction in New York (see 1899, Abstract No. 524). The cost of operating the conduit there obtained, viz., 5·03d. per car mile, or 37·9 per cent. of the receipts, throw a very favourable light upon this system. To convert the 37 miles of double track in Glasgow to the conduit system would cost approximately about £10,000 more per mile of double track than if the trolley were employed. Assuming 122,000 car miles per annum per mile of single track, the interest and sinking fund on the extra cost amounts to about ½d. per car mile. All possible items being included, the extra cost should not exceed 1d. per car mile. Owing, however, to local conditions, such as insufficient depth of road metal over bridges and railways, the initial outlay might be higher than the above estimate; and the author does not think the advantages of the system are sufficient to demand a trial. W. R. C.

628. *Passenger Locomotive Truck*. (Rly. World, 7. pp. 302–303, 1898.)—A description is given of a truck built by the Brill Company for one of the French railways. It is intended for a bogie motor car, 96,000 lbs. in weight, which is to be capable of hauling a train. As accommodation has to be provided for passengers, these trucks depart in detail considerably from the ordinary electric locomotive truck. W. R. C.

629. *Single and Double Truck Cars*. **J. J. Beggs.** (Rly. World, 7. p. 377, 1898, and Proceedings of American Street Railway Association.)—The author is in favour of double truck cars as they give rise to increased traffic, the travelling being easier than in single truck cars. Greater speed is possible, and at Milwaukee it has been found that more headway may be allowed without loss of traffic. The wear and tear is probably less than that which occurs with single truck cars. W. R. C.

630. *Allen and Peard's Mechanical Contact System.* Elect. Rev. 43, p. 963, 1898.)—The car wheel depresses a lever which raises a contact plate above street level, but the plate is not alive until the collector on the car has raised it further. The switch gear is attached to the lid of the boxes and can be quickly replaced. The inventors claim less cost than for trolley system. E. H. C.-H.

631. *Old Rails as Sleepers.* (Street Rly. Rev. 8. pp. 792–794, 1898.)—The Rochester Railway Company, N.Y., have used old 52-lb. rails as sleepers for their new 86-lb. rails with good results. W. R. C.

632. *Track Construction.* **T. H. Gibbon.** (Elect. Engin. N.Y. 26. pp. 370–371, 1898.)—The author discusses the defects of present track construction and suggests a compound rail consisting of three longitudinal parts, breaking joint. The author claims greater rapidity in laying, greater durability, and lower maintenance, but gives no figures as to cost. W. R. C.

633. *Preservation of Sleepers.* **W. H. Glenn.** (Street Rly. Rev. 8. pp. 890–891, 1898.)—The author draws attention to the advantages of creosoting sleepers for tramways and gives figures as to cost. W. R. C.

634. *Detroit Automatic Switch.* (Street Rly. Rev. 8. p. 889, 1898.)—An account is given of an automatic switch for points on tramways. An insulated section, in circuit with the switch mechanism, is introduced on the trolley line. Normally the switch is set in one direction. But if the motorman wishes to take his car on to the branch line he continues to take power when the trolley passes along this section (20 inches in length). If he wishes to keep on the main track he cuts the car motor off while passing the section. These switches are found to work well in Detroit. W. R. C.

635. *Energy Meters on Three- and Five-Wire Systems.* **P. Bary.** (Ind. Elect. 7. pp. 449–450, 1898.)—The author discusses the use of energy meters from the consumer's point of view; and shows by analysis that where a consumer is supplied by three or five wires, unless the system is in perfect balance, the energy meter will always register a greater amount of energy than is actually supplied. A. H. A.

TELEGRAPHY AND TELEPHONY.

636. *Economy in Charging Accumulators from Primary Batteries.* **L. Brunelli.** (L'Elettricista, April, 1898; also Écl. Électr. 17. pp. 248–250, 1898.)—With *n* telegraph circuits (each of resistance *r*) *n* batteries are required for the signals to be of uniform intensity whether one or more circuits are operating. A single accumulator will yield this result, and even when charged by primary cells it is an economy on such cells used directly.

If R is the external res. of one of the *n* circuits, and *r* the internal res. of the battery—

$$\frac{I}{i} = 1 + (n-1)\frac{r}{R-r}$$

That is, the current in a single signal is to the current sent in one of several simultaneous signals in the above ratio, which was 3 to 2 in a certain example with one primary battery. M. O'G.

637. *Telephone Repeater.* **K. B. Miller.** (Elect. World, 32. p. 348, 1898.)—A double-pole receiver is rigidly connected to a solid back transmitter and the whole placed in a vacuum. There is a well-defined gain in volume without loss of articulation.

M. O'G.

638. *Dielectric for Telephone Cables.* (Electrician, 41. p. 529, 1899.)—By diminishing the solid material 25 per cent., an improvement in capacity of 15 per cent. is obtained. This diminution is secured by using a gauze called "leno" instead of paper. M. O'Gorman exactly reproduced a Post Office cable and obtained the following relative results:—

	CAPACITY PER MILE, ALL WIRES TO LEAD.			Ins. Res. Megs. per Mile.
	Max.	Min.	Mean.	
"Leno" Cable	0·0715	0·0633	0·0668	2000
Paper Cables	0·0798	0·0743	0·0773	5000
	0·0794	0·0723	0·0777	„
	0·0737	0·0683	0·0721	„

M. O'G,